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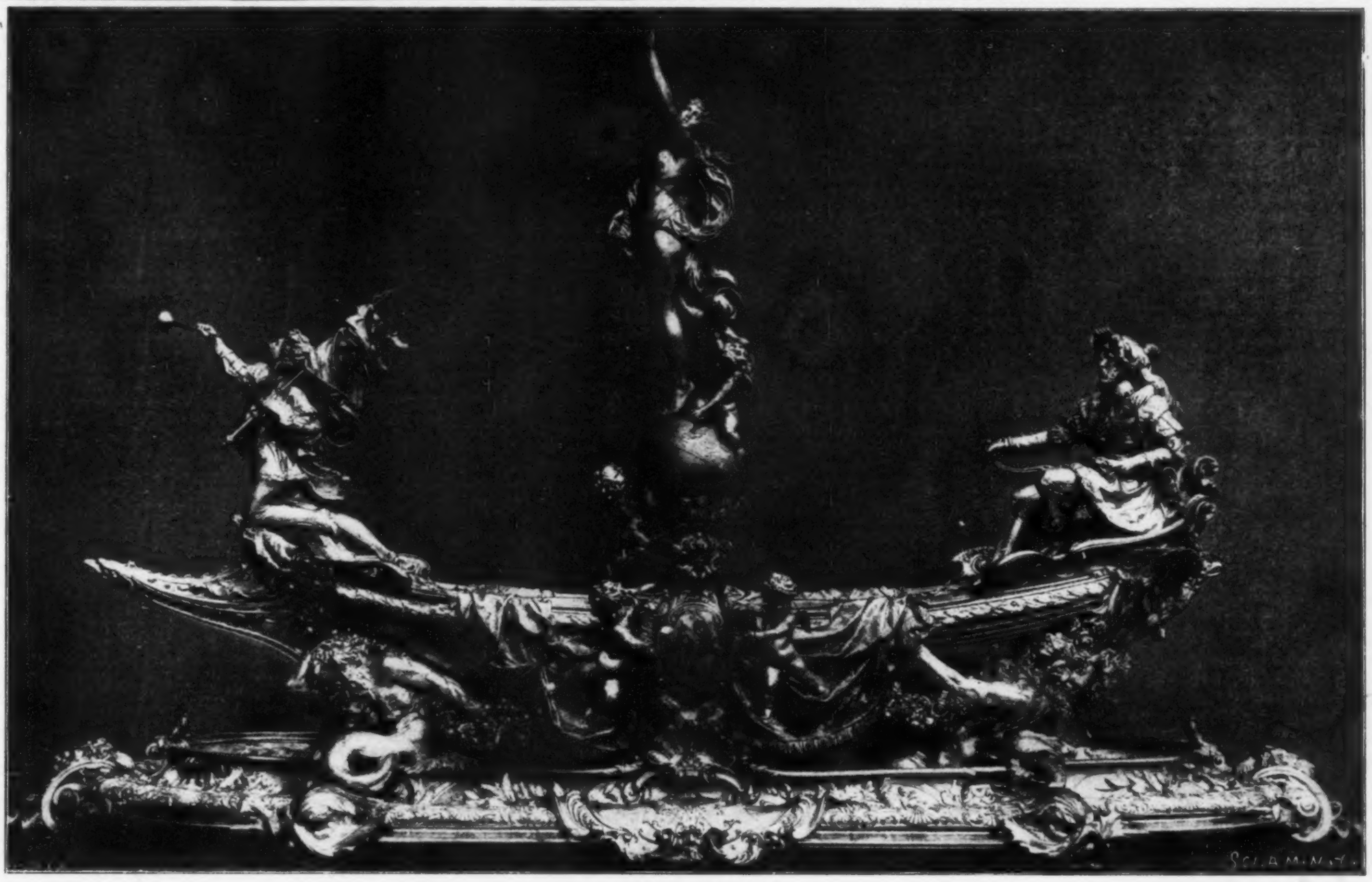
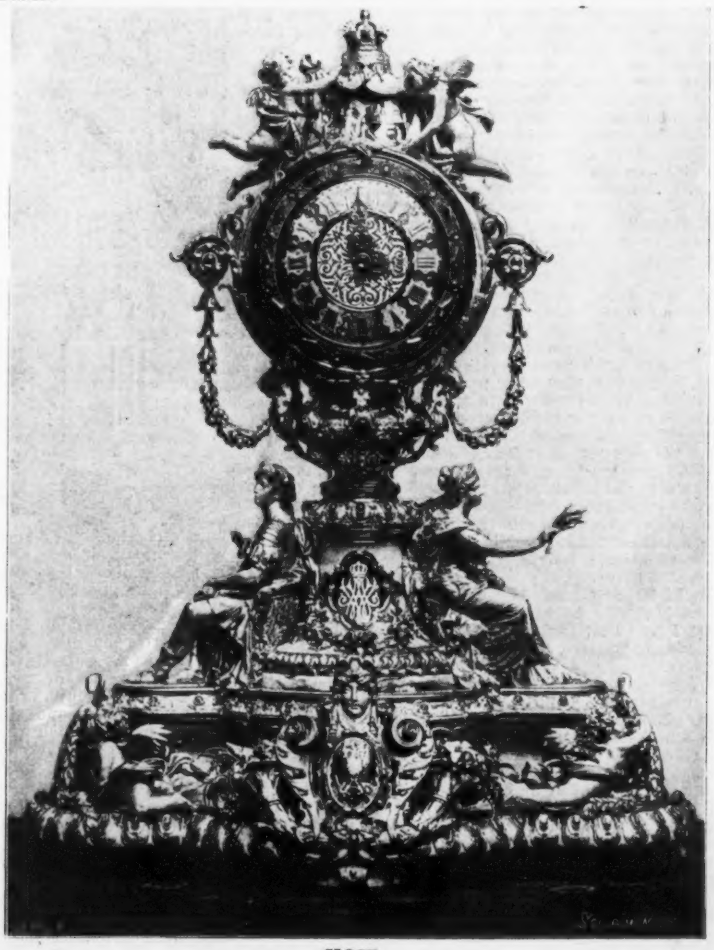


CENTER PIECE.

SILVER BEAKER.



CLOCK.

THE EMPEROR OF GERMANY'S SILVER SERVICE.

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NOT content with placing at his royal brother's disposal the imperial yacht, the Emperor of Germany saw to it that the Prince's table at official banquets would present an appearance worthy of royalty. For that reason the Kaiser gave orders to transfer part of his plate to the "Hohenzollern." It may be that at many of the almost innumerable dinners which Prince Henry in his swift course through the United States was compelled to eat, more costly pieces were used; but, be that as it may, the table service used on the "Hohenzollern" was assuredly imperial in its splendor. Among the pieces of unusual magnificence may be mentioned a center-piece which goes by the name "Das glückhafft Schiff," and is pictured on our front page illustration with such clearness that a description is hardly necessary. Other pieces of artistic merit are a clock, and a gorgeous silver drinking mug, so heavy that the man who attempts to empty it would need his two hands.

THE INERT CONSTITUENTS OF THE ATMOSPHERE.*

THE discovery of an element always awakens interest; for the total number of the known elements does not exceed seventy-five, and all the various forms of matter which exist on this globe are necessarily composed of these elements.

Elements must not be regarded as isolated entities, each self-dependent, having no relations with its compeers; on the contrary, all the elements exhibit certain connections with their neighbors; and there is to be traced an orderly progression from one class of elements, strongly electro-positive in character, metallic in appearance, very inflammable when heated in the air, and at once attacked by water, to another class, highly electro-negative, transparent, unattackable by oxygen, and without perceptible action on water, through a number of connecting links, each of which serves to soften the transition.

These elements have been arranged in series, and it is by considering the method of arrangement that our interest is awakened.

The revival of the hypothesis of the atomic constitution of matter by Dalton and of his attempt to determine the atomic weights of the elements was not long in provoking the guess that perhaps there could be found some connection between the numbers representing the relative atomic weights of kindred elements. But, as is well known, the state of knowledge in Dalton's day was not sufficiently advanced to enable him to attribute to elements their correct relative atomic weights; and it was not until the eminent professor of chemistry in Rome, Cannizzaro, whose jubilee has recently been celebrated, pointed out the bearing on Dalton's numbers of all the facts accumulated up to the year 1856 that the close relationship between the atomic weights and the properties of the elements was suggested by John Newlands. Some years later Lothar Meyer and Dmitri Mendeléef amplified and elaborated the ideas which had first been propounded by Newlands; and the periodicity of the atomic weights and the gradual variation of the properties of the elements and their compounds were established on a firm basis.

The division of the elements into metals and nonmetals corresponds broadly with another well-marked division—that into basic and acidic. Generally speaking, it is the oxides of the metallic elements which react with water to form bases, and those of the nonmetals whch form acids with water. According to modern ideas, bases, by the mere act of solution in water, are supposed to be split up into portions, for which the term ion, invented by Faraday, has been retained; one ion is charged by the process of solution with a positive charge, and that portion is usually a metal; the other portion, which consists of one or more groups of hydrogen and oxygen in combination, termed "hydroxyl"—OH—has a negative charge. A base, indeed, is a compound which splits in this manner. On the other hand, an acid, when dissolved in water, undergoes an analogous split; but in this case the electro-positive ion is always hydrogen, while the electro-negative ion may either be an element such as chlorine, or a group of elements such as exist in nitric acid (NO_3).

The order of the various elements in the electric series has been determined; and not merely determined, but to each has been attached a numerical value. This value is identical with what is termed "chemical affinity"; and it represents the electric potential of the element with reference to an arbitrary starting point, which does not differ much from that of nickel, an element closely related to iron. Only a few such values have as yet been determined numerically; instances may be chosen from the magnesium group, where the numbers run: Magnesium = + 1.2; Zinc = + 0.5; Cadmium = + 0.19; or from the fluorine column, where the numbers are: Fluorine = — 2.0; Chlorine = — 1.6; Iodine = — 0.4. In each case the potential, positive or negative, is the highest for the element with smallest atomic weight, and decreases with increase of atomic weight, for elements in the same column. The order of some of the elements is: Cs Rb K Na Li Ba Sr Ca Mg Al Mn Zn Cd Fe″ Co Ni Pb H Cu Ag Hg′Pt″″ Au‴; and for electro-negative ions, S″ O″ I Br Cl F; the first element, cæsium, being the most electro-positive, and the last, fluorine, the electro-negative.

The order given above corresponds fairly well with the order in the periodic table, passing from left to right. But, as in the table, the atomic weights follow each other continuously round the cylinder or round the spiral, the abrupt change from elements of an extreme electro-negative character like fluorine to sodium, an element of highly electro-positive character, or from chlorine to potassium, has always appeared remarkable. The old dictum, *Natura nihil fit per saltum*, if not always true (else we should have no elements at all, but a gradual and continuous transition from one kind of matter to another—a condition of affairs hardly possible to realize), has generally some spice of truth in it; and it might have been predicted (and the forecast seems to have been made obscurely by several speculators) that a series of elements should exist which should exhibit no electric polarity whatever. Such elements, too, should form no compounds, and, of course, should display no valency; they should be indifferent, inactive bodies, with no chemical properties.

The discovery of argon in 1894, followed by that of terrestrial helium in 1895, and of neon, krypton and xenon in 1898, has shown the justice of the foregoing remarks. Inasmuch as the methods employed for the isolation of these elements illustrate their properties and confirm the views as to their inertness and lack of electric polarity, I propose to sketch shortly the history of their discovery.

An accurate investigation of the density of atmospheric nitrogen and of nitrogen prepared from its compounds led Lord Rayleigh to inquire into the cause of the density of the nitrogen of the atmosphere exceeding that of "chemical nitrogen" by about one part in two hundred, whereas the accuracy of his experiments was such that it would have excluded an error of one part in five thousand. I need not here allude to the reasons which were at first put forward to account for this anomaly; suffice it to say that they offered no explanation; and that we ultimately traced the discrepancy to the presence in "atmospheric nitrogen" of a gas nearly half as dense again as nitrogen.

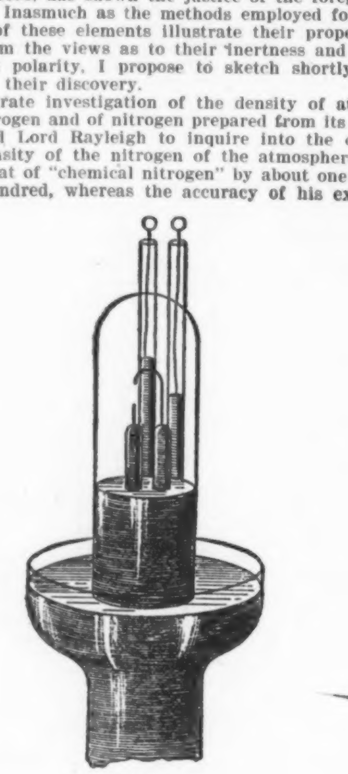


FIG. 1.

A convenient form of apparatus for isolating this gas is shown in Fig. 1. The gas, air mixed with oxygen, is confined over mercury in an inverted test-tube, in contact with a few drops of a solution of caustic potash; and by connecting the rings with wires from the secondary coil of an induction apparatus, sparks pass between the platinum terminals in the interior of the test-tube. The volume of the gas rapidly diminishes; and in a few hours the gas is removed to a clean tube, and the excess of oxygen absorbed by burning phosphorus; the inert gases remain behind.

On a larger scale, the apparatus used by Lord Rayleigh, consisting of a balloon of six liters' capacity, in the interior of which an electric flame is kept alight by means of a transformer, while a jet of caustic alkali forms a fountain in the interior, gives good results. By its help seven or eight liters of mixed gases can be made to combine per hour.

Such experiments show the inactive nature of the argon group of gases toward an electro-negative element, oxygen. The gases are absolutely incombustible. No other elements can withstand such treatment, save platinum and its congeners and gold. But even these metals combine with fluorine or chlorine when heated in a current of one or other gas. Argon, however, is wholly unaffected when electric sparks are passed through its mixture with chlorine or fluorine, the two other most electro-negative elements. To them, too, it shows itself completely indifferent.

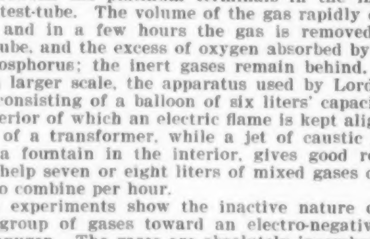


FIG. 2.

A more convenient method of separating the nitrogen from its admixture with argon in atmospheric air is by means of red-hot magnesium. The metal magnesium, which is now made on a considerable scale for photographic and signaling purposes, is a white, silvery metal, which can be planed or turned into shavings. In the early experiments a measured quantity of atmospheric nitrogen dried by passing over suitable drying agents was brought into contact with magnesium turnings, heated to redness in a tube of hard glass. It has been found, however, by M. Maquenne that the metal calcium, which, for this purpose is most easily produced by heating together a mixture of magnesium filings and pure dry lime, is a more efficient absorbing agent for nitrogen, for it does not require such a high temperature and can be effected without danger of melting the glass tube. Indeed, the operation is a very easy one and can be carried out with the very simple apparatus shown in Fig. 2. M. Guntz has also found that lithium, an element belonging to the same column in the periodic table as sodium and potassium, is an exceedingly good absorbent for nitrogen, for it tarnishes in nitrogen even at atmospheric temperature owing to the formation of a nitride.

On a large scale the magnesium turnings are contained in iron tubes and the gas-holders are made of copper or of galvanized iron. By this means fifteen liters of argon were separated from about two cubic yards of air.

The inactivity of argon in contact with such highly electro-positive elements as lithium, magnesium and calcium again demonstrates its want of electric polarity. No other element would have resisted such treatment except those of the argon group. But these are not the only data from which such a conclusion can be drawn, for it was found that no action takes place between argon and hydrogen, phosphorus, sulphur, tellurium, caustic soda, potassium nitrate, sodium peroxide, sodium persulphide, nitro-hydrochloric acid, bromine water and many other reagents which it would be tedious to mention, all of which are remarkable for their chemical activity. We may therefore take it that the name "argon," which means "inactive," has been happily chosen.

In attempting to form compounds of argon, however, another consideration was not lost sight of; if compounds of argon were capable of existence they ought to exist in nature, and, as in all probability they would be easily decomposed by heat, it ought to be possible to decompose them with evolution of argon, which could be collected and tested. Prof. Miers, in a letter which he wrote me the day after an account of the fruitless attempts to cause argon to combine had been given to the Royal Society, drew my attention to experiments by Dr. Hillebrand, of the United States Geological Survey, in course of which he obtained a gas, which he believed to be nitrogen, by treating the rare mineral clevite, a substance found in feldspathic rocks in the south of Norway, with sulphuric acid. The chief constituents of clevite are oxides of the rare elements uranium and thorium, and of lead. The gas obtained thus, after purification from nitrogen, was examined in a Plücker tube with the spectroscope and exhibited a number of brilliant lines, of which the most remarkable was one in the yellow part of the spectrum, similar in color to the light given out by the glowing tube. The position of this line, and of others which accompany it, established the identity of this gas, not with argon, as was hoped, but with a supposed constituent of the sun's chromosphere, first observed by M. Janssen, of Paris, during an eclipse which was visible in India in 1868. The late Sir Edward Frankland and Sir Norman Lockyer, who studied the spectrum of the chromosphere, gave to the suppositious element, which they regarded as the cause of these lines, the name "helium," a word derived from "ἥλιος," the Greek for "the sun." Having been placed on the track, I examined, with the assistance of Dr. Collie and Dr. Travers, no fewer than 51 minerals, while Sir Norman Lockyer examined 46 additional ones, which we had not examined, and in 19 minerals, almost all of them containing uranium, helium was found. Only one gave an argon spectrum, namely, malacone. We also sought for argon and helium in meteorites, which all give off gas on heating; but in only one specimen, a meteorite from Augusta County, Virginia, was helium found, in this case accompanied by argon. All natural waters contain argon, for that gas is somewhat soluble in water (4.1 volumes per 100 of water at 15 deg. C.); but some also contain helium, as, for instance, the gas from the Bath springs, which Lord Rayleigh found to contain argon mixed with about 8 per cent of its volume of helium; and helium has also been found in mineral springs at Wildbad, and at Cauterets, in the Pyrenees. It would appear, then, that helium is not such a very rare constituent of our globe; and indeed, it is probable that it is continually escaping from the earth in small quantities in certain regions.

In 1897, as president of the Chemical Section of the British Association, I chose the title "An Undiscovered Gas" for the address to the Section. The arguments in favor of the existence of such a gas were briefly these: The differences between the atomic weights of consecutive elements in the columns of the periodic table are approximately 16 to 20; thus 16.5 is the difference between the atomic weights of fluorine and chlorine; 16 between those of oxygen and sulphur, and so on. Again, stepping one pace down the scale, we have 19.5 as the difference between chlorine and manganese; 20.3 between sulphur and chromium; 19.8 between silicon and titanium, etc. The total difference between manganese and fluorine is 36; between chromium and oxygen, 36.3; between vanadium and nitrogen, 37.4; and between titanium and carbon, 36.1. This is approximately the difference between the atomic weights of helium and argon, 36. I quote now from that address: "There should, therefore, be an undiscovered element between helium and argon, with an atomic weight 16 units higher than that of helium, and 20 units lower than that of argon, namely, 20. And if this unknown element, like helium and argon, should prove to consist of monatomic molecules, then its density should be half its atomic weight, 10. And pushing the analogy still further, it is to be expected that this element should be as indifferent to union with other elements as the two allied elements."

Those who care to read the story of the search for this undiscovered element may find it in the address. Minerals from all parts of the globe, mineral waters from Britain, France and Iceland, meteorites from interstellar space; all these were investigated without results. Helium from various minerals was separated by long and tedious processes of diffusion into a possibly lighter portion, diffusing more rapidly, and a possibly heavier portion diffusing more slowly, but with no positive result. The systematic diffusion of argon, however, gave a faint indication of where to seek for the missing element, for the density of the more rapidly diffusing portion was 19.93, while that of the portion which diffused more slowly was 20.01.

The invention by Dr. Hampson of an apparatus by means of which it is possible to obtain liquid air at small expense and with little trouble placed a new instrument in our hands; and Dr. Travers and I pre-

* Abstract of an evening lecture delivered at the meeting of the British Association at Glasgow, September 13, by Prof. W. Ramsay, F.R.S.

pared 15 liters of argon from the atmosphere, with the purpose of distilling it fractionally, after liquefaction; for we know, from the researches of Prof. Olszewski of Cracow, who has done so much to determine the properties of liquefied gases, that argon could be liquefied easily by compressing it into a vessel cooled by help of liquid air. And, moreover, we were in hope that by fractionating the air itself gases of even higher atomic weight than argon might possibly be obtained. Both expectations were realized; on distilling liquid argon the first portions of gas to boil off were found to be lighter than argon, and on allowing liquid air to boil slowly away heavier gases came off at the last. It was easy to recognize these gases by help of the spectroscope, for the light gas, to which we gave the name *neon*, or "the new one," when electrically excited emits a brilliant flame-colored light; and one of the heavy gases, which we called *krypton*, or "the hidden one," is characterized by two brilliant lines, one in the yellow and one in the green part of the spectrum. The third gas, named *xenon*, or "the stranger," gives out a greenish-blue light and is remarkable for a very complex spectrum, in which blue lines are conspicuous.

Although neon was first obtained by the fractional distillation of argon, it was afterward found convenient to prepare it direct from air. The torpedo-compressor, which is used for compressing the air before it enters Dr. Hampson's liquefier, was made to take in the air which had escaped liquefaction in the liquefier; the denser portions were thus liquefied, and the lighter portions were liquefied by compressing them into a vessel cooled by the denser fractions, boiling under reduced pressure, and consequently at a specially low temperature. This liquefied portion was again fractionated, and yielded neon; and it was not long before we discovered that helium was also present in the mixture. The presence of helium in atmospheric air had previously been noted by Prof. Kayser of Bonn, and by Prof. Friedländer of Berlin, on submitting the spectrum of argon to a searching examination.

The purification of this mixture of neon and helium from argon, although a lengthy process, was not attended by any special difficulty. It was accomplished by repeated distillation, the lighter portions being always collected separately from the heavier portions, and again distilled by themselves. But after this separation had been accomplished, we found that we were unable by means of liquid air to liquefy the mixture, or indeed any portion of it. We effected a partial separation by diffusion; but it is not possible to separate by this method two gases of which the quantity is limited. Another attempt was made by dissolving the gases in liquid oxygen, on the supposition that neon might prove more soluble than helium; but without satisfactory results. It was evident that a lower temperature than that possible by help of liquid air was necessary.

Prof. Dewar had by that time succeeded in producing liquid hydrogen in quantity, and had indicated the principle, which is identical with that of Dr. Hampson's air-liquefier, although he has not published any detailed account of his apparatus. Dr. Travers undertook to investigate the subject; and after four unsuccessful trials he made a liquefier, with the help of Mr. Holding, the laboratory mechanician, by means of which a hundred cubic centimeters of liquid hydrogen could be easily and cheaply produced. There was then no difficulty in effecting the separation of neon from helium; for, while neon is practically non-volatile, when cooled by liquid hydrogen, remaining in the state of solid or liquid, even that enormously low temperature is not sufficient to convert helium into a liquid. Hence the gaseous helium could be pumped away from the non-gaseous neon, and the latter was obtained in a pure state.

The residues obtained from the evaporation of about thirty liters of liquid air, after being freed from oxygen and nitrogen, were liquefied by help of liquid air, and fractionated from each other. The separation offered no special difficulty, but was long and tedious. It soon appeared that when most of the argon had been removed the residue solidified when cooled; but while it was possible to remove the krypton by pumping, for it goes into gas slowly even at a low temperature of liquid air, very little xenon accompanied it; for at that temperature xenon is hardly at all volatile.

Having finally separated the gases, their densities and other properties were carefully determined; and it was also proved that they were like argon and helium, inasmuch as their molecules consist of single atoms. Neon, as was expected, turned out to be the missing link between helium and argon; the atomic weight of krypton was found to be 81.6, and that of xenon 128. The volumes occupied by equal numbers of molecules of the liquefied gases were determined; and also the boiling-points and melting-points of argon, krypton and xenon. These figures are shown in the following table:

	Helium.	Neon.	Argon.	Krypton.	Xenon.
Density of gas....	1.98	9.96	19.96	40.78	64.0
Atomic weight.....	3.96	19.92	39.92	81.56	128.0
Density of liquid...	0.3(?)	1.0(?)	1.212	2.155	3.52
Boiling-points......	—	—	-186.1°C.	-151.7°C.	-109.1°C.
Melting-points......	—	—	187.9°C.	-169.°C.	-140 °C.
Critical temperatures	—	—	-117.4°C.	- 62.5°C.	+ 14.75°C.
Critical pressures...	—	—(Meters.)	40.20	-41.24	43.50
Refractivity of gas..	0.124	0.235	0.968	1.450	2.368.

In every case there is seen what is termed periodicity; that is, a gradual alteration with rise of atomic weight, of the densities of the liquids, of the melting-points, of the boiling-points, and of the retardation of light when passed through the gas.

Let us consider, in conclusion, the position of these elements in the periodic table; and it will be sufficient to confine our attention to the groups of elements which form the neighboring columns. The atomic weights are given in round numbers.

Hydrogen. 1	Helium. 4	Lithium. 7	Beryllium. 9
Fluorine. 19	Neon. 20	Sodium. 23	Magnesium. 24
Chlorine. 35.5	Argon. 40	Potassium. 39	Calcium. 40
Bromine. 80	Krypton. 82	Rubidium. 85	Strontium. 87
Iodine. 127	Xenon. 128	Cæsium. 133	Barium. 137

It is evident that these new elements fall into their natural places between the strongly electro-negative elements of the fluorine group, and the very electro-positive elements of the lithium group, and that, in consequence of their lack of electric polarity and their inactivity they form, in a certain sense, a connecting-link between the two. It is curious, too, to notice that iodine, xenon, cæsium and barium form the ends of their respective columns. It is, of course, not impossible that other elements may be discovered possessing similar properties and yet higher atomic weights than these; but as yet there is no clew to guide us where to search for them.

It is difficult, owing to the impossibility of effecting a complete separation of the inactive elements from each other, to do more than hazard a guess as to their relative amount in air. As they are easily separated from the other constituents of air, there is no doubt as to their total amount; air contains 0.937 part of argon and its companions by volume in 100 parts. Perhaps the table below may be taken as affording some indication of their relative amounts. Air contains by volume:

0.937 part of argon per hundred.
One or two parts of neon per hundred thousand.
One or two parts of helium per million.
About one part krypton per million.
About one part of xenon per twenty million.

It is of course not impossible that xenon may contain an even smaller proportion of a still heavier gas; but it is unlikely. Sea-water sometimes contains a grain of gold per ton; that is one part in 15,180,000; a grain of xenon is contained in about four hundred-weights of air.

The problems suggested by the periodic table are by no means solved by the discovery of these aërial gases; but something has been done to throw light upon one obscure corner of the field. The gap between the electro-positive and the electro-negative elements has been bridged.—Nature.

AMERICAN COPPER PRODUCTION.

PRELIMINARY estimates of the output of copper in the United States last year indicate a falling off, the quantity reported being about 266,000 tons, as compared with over 276,000 tons for 1900. Seeing how strenuous—almost desperate—were the efforts of the Amalgamated Copper Company to secure a general curtailment in the interests of high values, and how materially this curtailment was carried on in the mines of the company itself (which now controls something like 50 per cent of the output), it is rather surprising that the decrease was relatively so inconsiderable. The Calumet and Hecla, and one or two others of the larger producers, did not increase their output, being generally content to give their negative support to the combine; but though details of the production of States are not yet available, and are not likely to be available for some months to come, it is a fair inference that the numerous small mines in Arizona, Colorado, New Mexico, Idaho, Nevada, Utah, and other States must have been turning out every pound of metal in their power, in order to benefit before the price should have fallen further. Evidence of feverish activity has been forthcoming in plenty, and it should not be forgotten that many mines floated at the time of the boom three years ago are now added to the list of actual producers, and are on their mettle, as it were, to show the share market that the depreciation of their values was not warranted. Individually, these mines, as producers, are of little account, but collectively they contribute a fair and, what is more, a growing share of the annual output of the whole republic. Not that there is any likelihood of any of them rivaling the three great copper-mining States. Copper is a very obtrusive metal. A few ounces of its decomposed compounds will stain a whole mountain side with green or blue, and a very small quantity will so affect the waters of all the streams running over it, especially in the dry season, that the attention of the prospector is immediately attracted to the fact, and he is sure to find out the cause. There are no such hidden recesses in the United States as are popularly supposed to conceal these wonderful deposits. Into every place where there is a chance of the occurrence of ores, and in ten thousand places where there is not, the prospector has penetrated over and over again, until every nook and corner of the American mountains is as familiar to some one or more mining men as are the streets of a city to one who is born there. "There are many districts, especially in Utah, California and Nevada," says Mr. E. D. Peters, formerly consulting chemist to the Calumet and Hecla, "that to-day offer inducements for examination; but there is no reason to expect any overwhelmingly large flood of this metal from any new mines, such as was poured upon the world's markets from the almost simultaneously discovered surface ores of Montana and Arizona and the cupriferous pyrites of the Iberian Peninsula." All the same, these small producers have not been exploited to their full extent; and while not phenomenally rich, it is being shown that they are capable of ranking much higher collectively than they have hitherto done. It is notorious that the yield of the three chief districts represents a tremendous annual dip into the reserves of the developed properties; and though Calumet and Hecla has at least another century of life, according to recent computations, few of the others promise to last anything like that space; and in a generation or two at the outside, the United States may be glad to think that it possesses ores only partially developed in localities at present dismissed under the curt heading of "Other States."

Of the three chief copper-bearing districts, Lake Superior, Montana, and Arizona, the second has in recent years made the most rapid progress, but it will probably be played out long before either of the others. Arizona has not enjoyed such facilities as its rivals, because it has only within very recent years been opened up adequately. It has to be said for it, however, that having made a start it did not move on leaden feet. To-day the industry is of vast importance to the State itself, and of no little importance in relation to the whole country's production. Moreover, it has not been caught in the paralyzing grip of the Trust, and that is a point which will tell in favor of its future progress. Nearly all the annual output of this State is obtained in three localities—the Bisbee, the Clifton, and the Globe—and the copper comes from a very small number of companies operating on a large scale. The characteristic feature of the ores of the three districts is that they are oxides and carbonates, from which metal 95 to 97 per cent fine can be obtained from the one operation of smelting in the blast-furnace. This copper is of exceptional purity, and is shipped to refiners on the Atlantic seaboard to be converted into ingots and bars. The mines have opened large bodies of rich ores; but, on the whole, the average copper content is not as high as is usually stated. The furnace yield of sorted ores ranges from about 8 per cent at the Bisbee mines to 12 or 15 per cent at some of the others, the closeness of the sorting depending upon cost of fuel, etc. In Arizona the deposits are mostly oxidized ores; in Montana they are sulphurets with some silver (for which they were originally worked); and in the Lake Superior region native copper is worked. The Montana veins are in the neighborhood of Butte, and are inclosed within a rough rectangle having a length of 2½ miles and a width of about one mile. At its eastern end the mines are argentiferous, copper predominating in the west. A very large number of veins course through the granite hill. At the surface the copper contents were relatively low, silver being more perceptible; but when digging was carried down to the waterline at a depth of 50 feet to 150 feet, the vein filling changed somewhat suddenly in character, being heavily charged with copper sulphurets, copper glance and peacock copper predominating. Many of the veins are known to be large, their thickness rising to more than 100 feet, although the average does not exceed 8 feet or 10 feet. The great mass of the ore is not rich, and runs to from 4 to 10 per cent of metal. There are many mines in this region, but interests are in relatively few hands, the most prominent companies being the Anaconda, Boston and Montana, Butte and Boston, Parrott, and the Butte Reduction Works. The future of the district was at a very early date seen to depend upon the successful utilization, commercially and technically, of the abundant stores of low-grade ores rather than upon the extraction of occasional bunches of rich ground. This has been accomplished. The mining presents little difficulty, except that growing out of the excavation of great openings in such mines as the Anaconda and the St. Lawrence, where rock-filling has now become the main reliance. All of the Butte copper ores carry varying quantities of silver. For the whole State the output last year was nearly 100,000 tons. The total compares with 85,000 tons for the Lake Superior mines, with 55,000 tons for Arizona, and with 26,000 tons for the other States. Perhaps the feature of present-day mining in the Lake region is the low grade of the stuff that is worked profitably. The Atlantic mine has contrived to live and pay moderate dividends on a yield of only 0.60 to 0.70 per cent of copper; while the Quincy, the richest of its class, can claim only 2 per cent from sorted rock. The Calumet and Hecla from its richest ground takes only 4½ per cent ore, the average being 3¾ per cent. Formerly mass copper was plentiful; but, with the exception of Central, all the important mines are now working one of two classes of deposits interbedded in a lava in what is known locally as "trap"—the amygdaloid beds and the conglomerate beds. The chief difference between the two, from a practical point of view, is that the former are usually the softer, and can therefore be more cheaply worked, while the latter, being harder, require a richer ore to pay. To-day the most important of the first of the two classes are the Quincy, the Franklin, and the Atlantic mines, and the chief of the conglomerate class is the Calumet and Hecla, the most famous of all the Lake mines, whose riches are supposed to have been brought to light by the energetic rooting of a pig's snout: a picturesque story which has the misfortune of being untrue.

If the Amalgamated Copper Company is still restricting the output of its mines, the production of the independent mines must be on a phenomenal scale. The imports of copper into Europe from the United States last month (the shortest in the year) were 19,246 tons, which constitutes a record, comparing with 10,859 tons in January, 8,507 tons in December, and 6,833 tons in November. The previous best for any month during the last three years was the 18,289 tons of April, 1900. The price of the metal keeps in the neighborhood of 55l. per ton, but if the February shipments have not been helped by the combine in order to put the quotation lower in furtherance of its devious purposes, there may be an early fall again. But the consumption is also on a phenomenal scale, last month's takings running to 26,315 tons, against 18,754 tons in January. This also is a record total, the previous best in the three years being the 26,293 tons of December, 1899.—Engineering.

Automobile Trade in Belgium.—During the first eleven months of 1901, Belgian manufacturers exported to foreign countries 1,125,022 francs ($217,129.25) worth of automobiles, motocycles, and detached parts. During the same period only 119 vehicles (detached parts included), valued at 147,886 francs ($28,542) were imported.

The following shows the countries importing Belgian automobiles, motocycles, and detached parts, and the values:

	——Value.——	
Country.	Francs.	
England	398,465	$76,903.74
France	244,162	47,123.27
Holland	188,591	36,398.06
Germany	104,555	20,179.11

Belgium received from France 60 automobiles and 33 motocycles, and from Germany 6 automobiles and 5 motocycles; and delivered 48 automobiles to France, 62 automobiles and 59 motocycles to England, 18 automobiles and 13 tricycles to Germany, and 31 automobiles and 57 tricycles to Holland.

A meeting of delegates of the permanent deputations of the different provinces was held at Liege, Belgium, on March 1 for the purpose of establishing a uniform basis for the collection of provincial taxes on automobiles.—George W. Roosevelt, Consul at Brussels.

"ARTIFICIAL FLAGS" FROM BLAST FURNACE SLAG.

Various attempts have been made from time to time to utilize blast furnace slag in a commercially profitable way, but hitherto it has been principally used, and that only to a limited extent, for making or mending macadamized roads. A new use has, however, been recently found for it which bids fair to secure a handsome profit to those who undertake its manufacture into "artificial flags," suitable for street footways and floors of buildings.

"Artificial flags" have already been made from granite chippings or finely crushed stone, agglomerated with cement; and though these have hitherto been mostly made in a rather crude way, they have rapidly grown in use and favor on account of their being easily laid, and pleasing in appearance. Slag has an advantage over any natural stone on account of the large percentage of lime which it contains, which materially reduces the proportion of cement required for agglomeration. To produce the best quality of these flags, which shall be dense and durable, and with a smooth and level surface, a great pressure is required to be exerted on each flag in the process of manufacture; this reduces the time required for drying and hardening, but can be obtained only by a hydraulic press, which must also be rapid in its production. The consideration of the fact that there was considerable room for improvement in this direction, led to the design of their patent hydraulic revolving-type flag press, by Messrs. Henry Berry & Co., Ltd., Croydon Works, Leeds, who have made hydraulic machinery their specialty for over twenty years. This machine has a heavy revolving table, made in the form of a cross, takes the place of the sliding table of the single type machine, and two rams are provided, the first and most powerful being used only for pressing the flags, and the second for forcing the flags from the molds. The cross-shaped revolving table works on a fixed circular table, the upper face of which is planed to a smooth and perfectly level surface. Rectangular holes, corresponding with the largest size of flag which the machine will make, are formed in the four arms of the upper table, and the molds are bolted to this table.

Work commences at the mold at the extreme right. A loose but closely-fitting and perfectly true metal plate is first laid in the mold, and rests on the fixed circular table. This mold is then filled with concrete, and by means of the chain-gearing and rack a quarter-turn is given to the revolving table, which carries the filled mold to the position in front. Here the concrete is leveled, and a second quarter-turn carries the filled and leveled mold to the third position, under the powerful ram. The ram is then set in motion, commencing with a pressure of 500 pounds per square inch, which is increased by intensifying to about 4,500 pounds per square inch. When this operation has been completed, a third quarter-turn carries the flag to the fourth position under the small ram, which forces the flag and loose plate out of the mold and through a hole in the fixed table on to a trolley underneath. A fourth quarter-turn brings the mold round to its first position.

BERRY HYDRAULIC FLAG PRESS.

Of course, all the four operations are in progress at the same time, four men or boys being constantly employed at the machine. One does nothing but fill the molds, the second levels and smooths the concrete, the third attends to the large ram, and the fourth confines himself to forcing the flags from the molds by means of the small ram.

The machine is adapted for making flags of the following sizes: 2 feet by 2 feet, 2 feet by 2 feet 6 inches, 2 feet by 3 feet, 2 feet 6 inches by 2 feet 6 inches, and 2 feet 6 inches by 3 feet. Different molds and different ramplates must of course be used for different sizes of flags, and consequently all these must be changed when a change of size is required.

By means of this machine flags can be made at the rate of about one a minute, at least double the speed of the ordinary machine. And in addition to the saving of time, there is also a saving of power due to the use of the small ram for forcing the flags out of the molds. This ram has a power of about 10 tons only, while the large ram is capable of working up to about 500 tons.

Each press is provided with the necessary hydraulic installation, including pumps, accumulator and intensifier, and the total weight of a machine of the size here described is about 32 tons. The great weight of the machine and the enormous power which it exerts necessitate foundations, in order that there may not be any jarring or settlement.

It is claimed, and perhaps with justice, that the revolving-table machine is a great improvement on previous types, and well worth the consideration of those who contemplate laying down plants for the manufacture of artificial flags. It has the great advantage of rapidity of action, economy of power, and ease of manipulation. It is adapted for making flags of different sizes, the necessary changes of frames being effected without much difficulty. A further advantage is that the machine occupies a comparatively small space.

THE LATEST OF THE BIG LOCOMOTIVES.

The American Locomotive Company, of Schenectady, have lately turned out a locomotive which is by far the largest and most powerful in existence. It was constructed for hauling heavy freight on the mountain division of the Santa Fé Railroad. Not so very long ago, the world was filled with wonder, and some measure of doubt, at the announcement that a 100-ton locomotive had been constructed; but the Santa Fé machine is about one-third heavier than that, its weight in working order being 130 tons, of which 116 tons is on the drivers and therefore available for adhesion. The weight given is that of the engine alone. The tender when loaded with 7,000 gallons of water and a full supply of its fuel of soft coal and oil, will weigh nearly 70 tons, so that the total weight of the locomotive and tender is in round numbers 200 tons. The total length of the engine, from the drawbar of the tender to the extreme end of the pilot, is 70 feet, and the height from the rail to the top of the smoke-stack is 15 feet 6 inches.

The locomotive is carried on twelve wheels. Ten of these are coupled, and upon them 116 tons of the weight of the engine is carried, this great total, therefore, being available for adhesion. With such a load on the drivers we naturally look for great size in the cylinders. These are built on the tandem-compound system, the high pressure and low-pressure cylinders on each side being arranged on the same longitudinal axis, a common piston rod doing duty for each pair. The high-pressure cylinders, which are $17\frac{1}{2}$ inches in diameter, are placed forward of the low-pressure cylinders, which are each 30 inches in diameter, the common stroke being 34 inches. When the locomotive is working up to its full power, the drawbar pull will be 27 tons.

To provide steam of over 200 pounds pressure in ample quantity to these large cylinders calls, of course, for a boiler of unprecedented size. The outside diameter of the first ring is 6 feet $6\frac{3}{4}$ inches. The firebox is 9 feet long, 6 feet 7 inches wide, and 6 feet 7 inches deep. There are 413 tubes, $2\frac{1}{4}$ inches in diameter and 18 feet 6 inches in length. The heating surface of the tubes alone is 4,476.5 square feet. The heating surface of the firebox is 205.4 square feet, and the total heating surface of the whole boiler reaches the enormous figure of 4,682 square feet. The grate alone has 59.5 square feet of surface. The boiler is of what is known as the extended wagon-top type, with wide firebox.

The driving wheels, which are of cast steel with tires shrunk on, are 57 inches in diameter. The slide valves are of the piston type; their greatest travel is 6 inches, the outside lap $\frac{7}{8}$ of an inch and the inside clearance $\frac{1}{8}$ of an inch for high-pressure and $\frac{1}{4}$ of an inch for the low-pressure cylinder. With such great cylinder power, and under the heavy loads on the drivers, we naturally look for large dimensions in the details of this great locomotive. The horizontal thickness of the piston is $5\frac{1}{2}$ inches; the high-pressure piston rod is $3\frac{1}{4}$ inches in diameter and the low-pressure piston rod is $4\frac{1}{2}$ inches in diameter. The main driving journal measures 10 inches by 12 inches, the other driving journals are 9 inches by 12 inches, and the engine truck journals are 7 inches by 12 inches. The total weight of the cylinders and saddle casting, as they lay in the molds, was 25,340 pounds. Next to the Santa Fé locomotive the largest engine in the world is the one built at Pittsburg for hauling mineral trains from the lakes to the Carnegie Works. This engine weighs 15 tons less than the Santa Fé locomotive, and its heating surface is about 3,800 square feet.

THE LATEST OF THE BIG LOCOMOTIVES.

FROM RAFT TO STEAMSHIP.

By Randolph I. Geare.

PART I.—PRIMITIVE FORMS OF VESSELS.

Seated astride a caballito, or raft consisting of a bundle of rushes lashed together, the orphan son of an Indian chieftain, with his entire body varnished and sprinkled with gold dust, propelled himself toward the middle of the lake, and having reached it jumped overboard, thus washing off the particles of dust as a sacrifice to the spirit of the waters. Having done this, he swam ashore amid the applause of the onlookers, who in their excitement had cast emeralds and other jewels into the water. In this fashion the young Indian was initiated as chief of the tribe. In the old Spanish literature he became "el hombre dorado"—the gilded man.

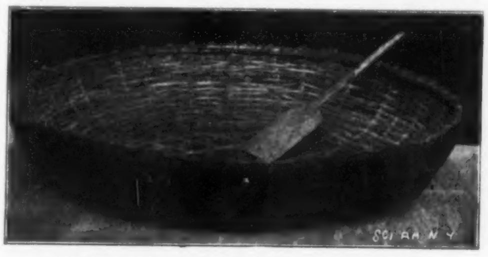
This rite has long been observed among a tribe of Indians dwelling near a lake in the mountains of Colombia, and in so doing they have perpetuated the use of one of the oldest forms of water-craft ever known to man.

Another early form of raft was a mere log or trunk of a tree, on which primitive man floated, first without rudder or paddle. But finding it necessary to guide his rude vessel, as well as to proceed at times against the stream, the next step was to provide himself with a pole or paddle. Then, in order to carry a heavier weight, perhaps his family or his household goods, he fastened several logs together to form a larger raft. Next, a single log was hollowed out, either by the use of fire or primitive tools, and thus was created the "dugout," the simplest form of canoe. Dugout canoes of a single tree have been associated with objects of the Stone Age among the ancient Swiss dwellings; nor are specimens wanting from the bogs of Ireland and the estuaries of England and Scotland, some having been obtained from as far as 25 feet below the surface.

On Lake Titicaca, in southern Peru, the usual form of transportation is by means of a "balsa," composed of two thick bundles of rushes laid parallel and fastened together. It is furnished with two masts leaning toward each other and fastened at the point of junction, thus somewhat resembling a pair of shears. The sails are made of rushes placed parallel to each other. The steersman holds in his hands, as though he were driving a horse, lines which are attached to the sail, and which correspond to our "sheets" and "braces." The vessel is steered with a stick trailed in the water. When the water is shallow the sail is lowered and the trail-stick, usually made of pepper-wood, then serves for a pole.

The balsa used on both the Atlantic and Pacific coasts of South America is usually a simple raft of parallel logs of some light wood, lashed together and steered by a paddle. It has one mast supporting a square sail. The most elaborate balsas are seen on the coast of Ecuador and consist of several logs of balsa wood, which are so light that a man can easily carry a large one on his shoulder. Upon them transverse logs or canes are lashed, forming a sort of deck, and on this deck a kind of house is not infrequently constructed. These balsas are provided with centerboards which extend down between the logs, forming a sort of keel, and this prevents the craft from drifting to leeward when sailing "by the wind." The natives handle them with much skill, and can make fair headway against wind and tide. The second illustration represents a sea-going balsa as used on the Peruvian coast.

In the Marianne or Ladrone Islands a dugout canoe was at one time in use. It was pointed at both ends, and was fitted with a lateen or triangular sail, supported by a gaff, the foot of the sail being stiffened by a boom. So swift and so easily managed was this craft that it called forth the admiration of all the early navigators visiting this group of islands. When sailing against the wind the sheet was shifted from the quarter to the bow, so that what had been the stern became the bow, and *vice versa*. A steersman sat at each end with a paddle, and thus directed the course of the canoe, that one *guiding* it who sat in the opposite end to the direction in which it was moving. It was usually provided with a platform, which extended to the outrigger, and upon this platform the passengers and freight were carried. Sometimes a smaller boat took the place of the outrigger. It was doubtless such a craft that Ulysses constructed when, having been directed to make a raft "with a raised platform," he selected trees "withered of old, exceeding dry, that might float for him." The natives of the Ladrone Islands seem to have entirely lost the art of making these canoes, although fortunately one or two specimens have been preserved in museums. The nearest existing form is the one now used by the Caroline Islanders.



SKIN-COVERED, BASKET CORACLE.

One peculiarity of the Ladrone Island canoe is that it was unsymmetrical in outline, the hull being very nearly rectangular on one side and curved on the other. The curved side was usually the lee side, and thus when the craft heeled over from the force of the wind its buoyancy was increased. The Polynesia dugout, common throughout the Malay Archipelago, is also furnished with an outrigger for going out to sea. It consists of a log rigidly connected with the canoe by cross-pieces, whose weight prevents the craft from capsizing to leeward, while the buoyancy of the log preserves its equilibrium, should it incline too far in the opposite direction. The force of the wind is referred to as a "one-man," "two-man," "three-man" breeze, etc., according to the number of men required on the outrigger to counterbalance the heeling of the canoe to leeward.

In the region of the Euphrates the ancients used to navigate the rivers seated on inflated goatskins, or goatskins were attached beneath the rafts to increase their buoyancy. Climatic influences and racial peculiarities imparted specific characteristics to the vessels, and, combined with the available choice of materials, determined the particular type for each locality. Thus, on the northwest coast of Australia is found the single log of buoyant wood, not hollowed out, but pointed at each end. Rafts of reeds are also found on the Australian coast. In New Guinea catamarans of three or more logs, lashed together with rattan, are the commonest form of vessel, and similar ones appear on the Madras coast and throughout the Asiatic islands. These were used with and without sails.

When timber began to grow scarce the bark alone was utilized as a covering for a light wooden frame, and thwart-braces were introduced to keep the sides in their proper positions. Birch-bark canoes are still used by the Indians of northern Alaska and many other localities. They are made with sharp, overhanging ends which rise to a point, and with flaring sides. At one end the canoe is decked for a distance of four or five feet. Another type, contemporaneous with the bark canoe, was the one in which the covering was made of skins.

A curious primitive form of canoe is the "coracle," which has been found almost similar in general appearance in the East Indies, in Alaska and in some parts of Ireland and Scotland. This is an open, saucer-shaped vessel. The one here described is of the kind used in the rocky torrents of the Bowani River in East India, where it is known as the "parachal." It consists of a light frame of split rattan covered with oil-cloth. It is about two feet ten inches in diameter and seven inches deep. In it the native sits, directing its course with a thin paddle. Assuming that these vessels are used in making social visits, it would seem necessary that if the occupant of the coracle wishes to reach home with a dry skin, especially if returning from a midnight feast, he should be very abstemious in his potations!

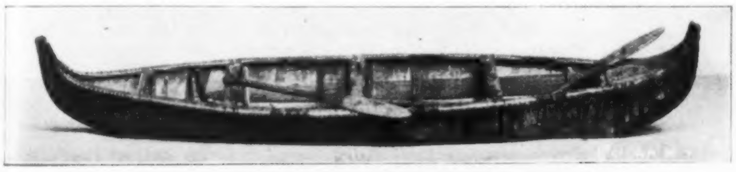
Before passing from this branch of the subject it will be interesting to note the more advanced types of canoes, such as the Madras surfboat, and those found in the Straits of Magellan and in Central Africa, as well as in the Malay Archipelago and in many islands of the Pacific. Some of these canoes show great advance in construction, being built up of pieces fitted together with ridges on their inner sides, through which the fastenings are passed. The body is constructed first and built to the desired shape, the ribs being inserted afterward and attached to the sides, their chief use being to unite the deck and cross-pieces with the body of the canoe. Vessels thus stitched together and with an inverted framework have from a very early time been constructed in the Eastern seas, some attaining to as much as two hundred tons burden.

From the stitched form the next step was to fasten the materials out of which the hull was built up by pegs or tree-nails; and of this system early types appear among the Polynesian islands and in the Nile boats described by Herodotus, the prototype of the modern "nuggur." The raft of Ulysses described by Homer presents the same detail of construction. Some of the early types of North Sea boats present an intermediate method, in which the planks are fastened together with pins or tree-nails, but are attached to the ribs by cords passing through holes in the ribs and corresponding holes bored through ledges cut on the inner side of each plank.

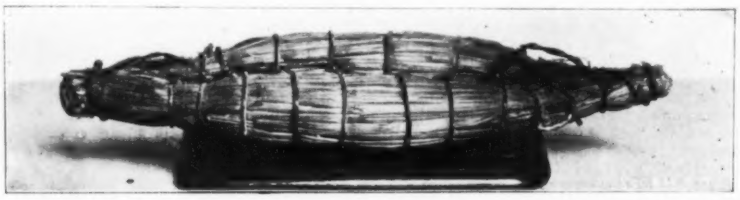
Thus is reached the stage from which the transition to the practice of setting up the framework of ribs fastened to a timber keel laid lengthwise, and subsequently attacking the planking of the hull was comparatively simple. The keel of the modern vessel has its prototype in the single log which, as we have seen, was the parent of the dugout. The side-planking of the vessel, which has an earlier parentage than the ribs, may be traced to the attempt to fence in the platforms upon the sea-going rafts or the sides of dugout canoes, so as to give them a raised gunwale. The ribs of the modern vessel are the development of the framework, and were originally inserted *after* the completion of the hull of the canoe or built-up boat, but are now *prior* in the order of construction. In other words, the skeleton of the hull is now *first* built up, and the skin, etc., adjusted to it; whereas in the earlier types of wooden vessels the outside hull was first constructed, and the ribs, etc., added afterward.

Primitive forms of vessels may, therefore, be thus roughly grouped:

1. Rafts, floating logs or bundles of brushwood, or reeds or rushes tied together.
2. Dugouts (hollowed trees).

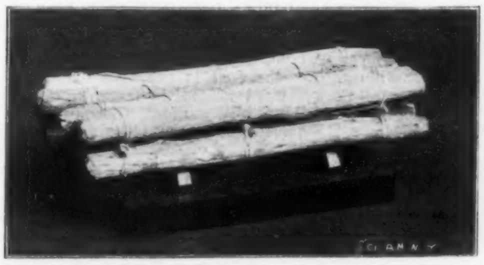


ALASKAN BIRCH-BARK CANOE.

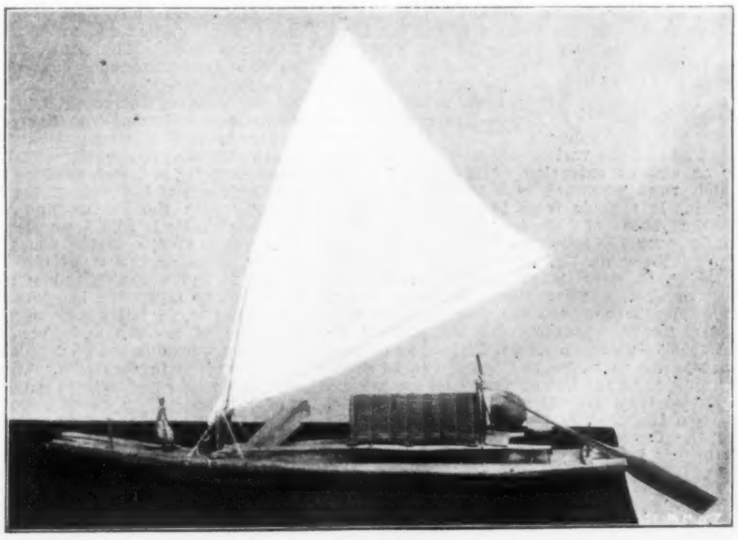


RAFT CONSISTING OF BUNDLES OF RUSHES LASHED TOGETHER.

SIMPLEST FORM OF DUGOUT.



RAFT OF LOGS LASHED TOGETHER.



EAST INDIAN CATAMARAN.

3. Canoes of bark, or of skin, stitched on framework or inflated skins (balsas).

4. Canoes or boats of pieces of wood stitched or fastened together with sinews or thongs of fibers of vegetable growth.

5. Vessels of planks, stitched or bolted together with inserted ribs and decks or half-decks.

6. Vessels of which the framework is first set up and the planking of the hull nailed on subsequently.

All these forms have survived in one shape or another in different parts of the world, with different modifications, marking phases of progress in civilization.

(To be continued.)

THE ROCKY MOUNTAIN COAL FIELDS.

The magnitude of the aggregate area of the Rocky Mountain coal fields is as yet scarcely appreciated. As described by Mr. L. S. Storrs in Part III. of the Twenty-second Annual Report of the United States Geological Survey now in press, they occupy about 60 per cent of the length of a belt along the eastern base of the main range, extending southward from the Canadian boundary fully 1,000 miles, through Montana, Wyoming, Colorado and New Mexico. Another less extensive belt occurs along the western base of the Rocky Mountain range in Wyoming, Utah, Colorado and New Mexico. Between these two belts, in the Park region, are numerous isolated basins. In addition to these generally bituminous fields, large areas of the plains of Montana, Wyoming and the Dakotas are also underlain by coal, usually lignite but valuable for local use. According to the latest estimates, the areas of the coal-bearing formations in the six States and one Territory of the Rocky Mountains are, for anthracite, bituminous and lignitic-bituminous coal, 43,610 square miles, and for lignite, 56,500 square miles. The history of the development of the various coal fields of the Rocky Mountains is essentially the history of the general development of the region, which has no parallel elsewhere in the United States, and in which, as in the case of the Western Interior coal field, the great transportation lines have been the determining factor.

The Colorado coal fields are the only ones for which a fairly accurate estimate of workable coal beds and available coal can be given. A conservative estimate places the workable beds at about 50 per cent of the total of 18,100 square miles of coal-bearing area, and the available coal at nearly 34,000 million tons. The Colorado fields have been divided into three groups, the eastern, the park, and the western. The fields of the eastern group are the Raton, the Canyon City, and the South Platte. The Raton field extends north from the Colorado-New Mexico line 45 miles along the base of the Front Mountain range and about 32 miles eastward into the plains, and embraces western Las Animas (the Trinidad district) and southern Huerfano (the Walsenburg district) Counties. Five of the forty coal beds are usually of workable thickness, varying from 8 feet down. The coal is both steam and coking. The Canyon City field is near Canyon City in Fremont County, east of the Wet Mountain range, south of the Arkansas River, and north of Newland Creek. Some of the beds are from 4 to 5 feet thick. The product is excellent domestic coal. The South Platte field begins a few miles north of Colorado Springs, and runs thence north along the Front range for about 140 miles nearly to the State line, its width being about 40 miles. One mining district of the field is immediately north of Colorado Springs, in El Paso County; there are five others northwest of Denver at Boulder, Marshall, Lafayette, Louisville, and Erie in Boulder and Weld Counties. The coal is essentially lignitic.

The Como district of the Park group is in northwestern Park County, and is 21 miles long, and from 3 to 5 miles wide. These beds show from 2 to 8 feet of coal. The coal is a good locomotive fuel. The North Park district comprises nearly the entire area of North Park in the northern half of Grand County. There are apparently three workable coal beds varying from 4 to 32 feet in thickness, and the coal is lignitic. This is the least developed of any district in the State, and there is no immediate prospect of further development. Of the western group, the Yampa district, on the drainage of the Yampa River in Routt and Garfield counties, has a number of beds, varying from 4 to 17 feet thick. The coal varies from bituminous to anthracite. This area is at present practically inaccessible. The Grand River district is prospectively the most valuable of the State, because of its extent and of the varied character of the coals. It forms the eastern extension of the Green River Basin, which runs westward into the Wasatch district of Utah. It extends from the State line eastward to the base of Mount Wheatstone near Crested Butte, over 150 miles, and from the drainage of the Yampa River on the north to the Gunnison River on the south, over 100 miles. The districts of the productive area, Crested Butte, Baldwin, Ruby, Coal Basin, Jerome Park, are the only portions now reached by railroads, and those are but slightly developed. Garfield, Mesa, Gunnison, Pitkin, and Eagle counties are partly in this area. From two to seven beds containing 32 to 106 feet of clear coal are known. The coal varies from semi-bituminous to anthracite. The coke from the Coal Basin district is remarkably similar to the Connellsville coke. The part of the South Platte field lying in Colorado extends, about 15 miles wide, from the Western State line 85 miles along the southern State line in La Plata County. The Durango district produces coking coal. The La Plata district adjoins it on the west. Four beds of coal are worked, varying from 4 to 20 feet in thickness, there being at one point near Durango 80 feet of coal in 100 feet of strata. The Tongue Mesa field between the Cimarron and the Uncompahgre rivers in Montrose County, contains two workable beds of lignite coal from 5 to 20 feet thick. At a number of places through the western part of the State south of the Grand River drainage, coal beds are exposed, but they are not of economic value. The coal fields of Colorado contain every variety of coal from the typical lignite to the equally typical anthracite. The area of the anthracite product probably does not exceed 8 square miles.

The coals of Wyoming, lying largely in the plains region, are of a lower grade, on the whole, than the mountain coals of Colorado and Montana. No good coking coal, nor any workable anthracite has yet been found within its limits; though the product from its mines finds a ready market along the line of the Union Pacific Railroad. In the Black Hills district, Crook County, there are two workable veins varying about 5 feet in thickness. Much of the coal is used for locomotive fuel. The Carbon district, the Hanna district, the Rawlins district, all in Carbon County, and all touching or crossing the Union Pacific line, contain some dozen different beds varying from 5 to over 20 feet thick. The coal is semi-bituminous and good for steam and domestic purposes. The Rock Springs district of Sweetwater County is on the main line of the Union Pacific. The three productive districts are Black Butte, Point of Rocks, and Rock Springs. A large undeveloped area extends for 30 miles north and south of the railroad. Six or eight beds, varying from less than a foot to 11 feet, are worked. The coal is semi-bituminous, and an excellent domestic fuel. The Hams Fork district in southern Uinta County on the Oregon Short Line has five beds, two of which, from 4 to 18 feet in thickness, produce semi-bituminous and lignitic coals. The Almy district, a few miles west of Hams Fork district in Uinta County, but on the Union Pacific line, has one workable seam with 22 feet of clear coal, which is a high grade lignitic. The Henry's Fork district, extending along the Wyoming-Utah boundary south of Rock Springs in Sweetwater County, has only one workable coal bed as yet discovered. The Teton district, unexplored and practically inaccessible, is in Fremont County near the head of Wind River between the Wind River and the Shoshone ranges. The Sublette district begins about twelve miles west of the Hams Fork district in Uinta County, and extends northwest into Idaho. The coal is semi-coking. The Big Horn Basin district extends from the State line in Fremont County southward 95 miles to the Owl Creek Mountains, with the Big Horn and the Absaroka ranges on the east and west respectively. Some development has taken place in the northwestern, central, and southern parts of the Basin. The coal is of a fair lignitic. The Wind River district lies in the central part of the State in Fremont County. The coal is semi-bituminous and the only development is near the crown of Lander. The narrow Caspar district in Carbon County extends eastward from the Rattlesnake Hills 30 miles around the northern end of the Laramie Mountains. The only development is a small mine producing lignitic coal near Casper. The Powder River district, some 8,950 miles, east of the Big Horn range, has plenty of lignitic coal of a low efficiency as fuel, but affording a limitless supply for the settlers of this treeless plain region. There are mines at Sheridan on the Burlington and Missouri Railroad; at Buffalo and Douglas; and in the southern end of the district on the Fremont, Elkhorn, and Missouri Valley road.

The coal fields of New Mexico lie chiefly in the northern part of the Territory. Only those parts adjacent to railroads have been thoroughly explored. The great value of these fields is in their proximity to an extensive region in Arizona, Texas, Southern California, and Mexico, in which very little coal of value has been found. The Raton district in Colfax County is the southern end of the Colorado Raton district, and extends from the State line 40 miles south to the Cimarron River, and 50 miles east from the Rocky Mountains. The workable coal beds vary from 3 to 6 feet in thickness, and produce a good coking coal. The main line of the Santa Fe crosses the field near its center. The San Juan Basin extends south of the Colorado line into the northwestern corner of the Territory, and the La Plata district of Colorado is found in both San Juan and Rio Arriba counties of New Mexico; but there are no mines of any magnitude in the New Mexico part of the district. The Mount Taylor district lies in Valencia and Bernalillo counties northeast of Grant Station on the Santa Fe and north of Mount Taylor. The two beds produce a lignitic coal, but no mines are in operation. The Gallup district, in Bernalillo and Valencia counties, lies north and south of the Santa Fe road for more than 75 miles, and forms the southern end of the San Juan Basin. The mines of Gallup and Clarkville produce semi-bituminous coal which finds ready markets for domestic and manufacturing fuel as far west as Los Angeles, including the United Verde smelters of Jerome, Arizona. The Los Cerrillos district of 35 square miles lies in central Santa Fe County, 20 miles south of Santa Fe. The three coal beds, varying in thickness from 2½ to 7 feet, produce good anthracite at the northern end of the district, the coal toward the south passing into the coking and semi-coking varieties. The anthracite is sold from Denver to San Francisco. The Tejon area, covering about 35 square miles, lies a few miles southwest of the Los Cerrillos district. There is one workable bed of clean, semi-bituminous coal, but no mines are in operation. The small Jarillosa district, 25 miles west of the Santa Fe road, on the line of Socorro and Valencia counties, contains only one workable bed of excellent coking coal. There are no mines in operation. The Carthage areas consist of a number of isolated patches, of about 60 square miles in extent, in Socorro County, 8 miles east of San Antonio on the Santa Fe road. Only a small amount of coal is mined. The White Oaks district in Lincoln County, extends north 40 miles from Three Rivers, and includes the Carrizo and Nogal Mountains. The five beds, from 4 to 5½ feet in thickness, produce coal ranging from semi-coking and coking to anthracite. The small Mora County area is in extreme northwestern Mora County, and cut off by a desert; and the small Gila River area is in northern Grant County, and was formerly mined to supply the mining camps around Silver City.

The areas of the coal-bearing rocks in Utah have been so little explored that the probable productive area of the State cannot be accurately estimated. The coal from the producing mines is nearly all semi-bituminous. The Wasatch district extends for 60 miles in San Pete, Emery, and Wasatch counties along the base of the Wasatch Mountains, thence eastward 140 miles past the Roan Cliffs to the Colorado line, and thence north through Uinta County to the Uinta Mountains. Sunnyside and Castle Gate in Emery County, and Pleasant Valley in San Pete are the producing centers. The coal from Pleasant Valley and Sunnyside is semi-bituminous; that from Castle Gate is a coking coal. The Coalville district, near the southwestern corner of Wyoming, 50 miles northeast of Salt Lake, in Summit County, has two workable beds and five mines and produces a semi-bituminous coal. The small Provo Canyon area near Provo in Utah County has not yet produced any coal of economic value. The Southern Utah district is but little known. It extends from the hills back to Cedar City in Iron County southeastward 150 miles nearly to the Colorado River. The coal is semi-bituminous, becoming lignitic toward the east. The Henry Mountain district in Pinto County produces a small amount of semi-bituminous coal consumed by the mining camps along the Colorado River.

The coal of North Dakota is lignitic and disintegrates so rapidly upon exposure that it must be used very soon after leaving the mine. In many places it is only necessary to scrape off the surface in order to quarry the coal.

The coal fields of eastern Montana extend into northern Dakota, covering its southwestern portion as far as Emmons, Burleigh, and McLean counties, on the eastern side of the Missouri. The principal mines in this field are at Lehigh in Burleigh County, and Sims in Horton County, on the line of the Northern Pacific, and at Wilton and Washburn, 30 miles north of Bismarck, on the Bismarck, Washburn and Great Falls Railroad. The coal is lignitic. The mines of the Mouse River district are located along the lines of the Great Northern at Minot, and on the "Soo Line" at Burlington and Kenmore, all in Ward County. The coal is lignitic.

No mines of economic importance are operated in South Dakota, the only portion of the State underlain by coal being the northwestern tier of counties—Ewing, Hardin, Martin, and Butte; and no thorough explorations of these have been made.

The only point in Nevada at which coal of any value has been found is in the Eureka district, extending 30 miles south from Carlin on the Central Pacific in Elko County. The single bed is occasionally of workable thickness; but the coal is lignitic and impure; and there are no mines in operation.

No coal is mined in Idaho on a large scale. The Boise district, in front of the Boise Mountains and between the Boise and Payette rivers, extending north 30 miles from a point six miles north of Boise, includes the Horseshoe Bend district, with one three-foot, high grade lignitic bed, and the Jerusalem district with four beds, from 3 to 8 feet thick, of lignite. No mines are in operation.

The coal fields of Montana form a nearly continuous belt extending in a northwest-southeast direction entirely across the State; but most of the fields have not been investigated in detail. As in Wyoming the plains region east of the Rocky Mountains, extending into the Dakotas is underlain by beds of lignitic coal of varying quality. The Bull Mountain district of 55 square miles lies in Yellowstone County about 45 miles northeast of Billings on the Northern Pacific road. The bed is from 10 to 16 feet of lignitic coal. But little coal is now mined there. The Clarks Fork district crosses the Yellowstone 22 miles west of Billings and extends north to the Musselshell River, though without known valuable beds. Southward the beds are workable in the Big Horn Basin district of Wyoming. The bed worked is from 3 to 5 feet thick and produces a good lignitic coal, chiefly marketed over the Northern Pacific at Butte City. The Rocky Fork district, three miles west of Clarks Fork district, has five workable beds of coal between lignite and bituminous, excellent for domestic and steam fuel. The only mine operated is at Red Lodge, owned by the Northern Pacific, which gets from it much of its locomotive fuel. The Yellowstone district can be followed for 150 miles from the eastern end on Boulder River in Gallatin County, through the Boulder, Livingston-Bozeman, and Sixteenmile and Shields River Basins, thence circling around the northern and eastern end of the Crazy Mountains and connecting with the western end of the plains field. The product is good steam and coking coal. The small Trail Creek basin is 9 miles south of the Northern Pacific at Mountain Side, and only a mile from the Yellowstone district, from whose coal its product differs entirely, being semi-bituminous and yielding a large proportion of lump coal. The Cinnabar district extends on both sides of the Yellowstone River northward from the Yellowstone National Park. There are four workable coal beds, which produce good coking coal, and also semi-anthracite. Only one mine is operated. The West Gallatin district, along the headwaters of the West Gallatin River, about 75 miles south of the Northern Pacific at Bozeman, is little known; it will probably produce a good coking coal. The Ruby Valley district, 30 miles west of the Gallatin district, is still less known. The small Toston district, 3 miles south of Toston and crossed by the main line of the Northern Pacific, could probably be operated on a small scale as the coal is coking. The Belt district, extending westward 125 miles from the Judith River in Meagher County, lies along the northern base of the Little Belt Mountains, and their westward extension on the west side of the Missouri River. The thickest point of the workable bed is near Sandcoulee in Choteau County, and yields both steam and coking coal. The Sweet-Grass Hills district, Choteau County, has three workable beds of fair semi-bituminous steam coal, but there are no producing mines. Along the summit of the Rocky Mountain range, and westward, are numerous areas of Neocene Lake beds, which contain some lignitic coal.

In 1880, the Rocky Mountain coal fields produced about 1,000,000 short tons of coal; in 1890 they produced about 6,200,000 tons; in 1900 about 13,500,000 tons, and their estimated capacity was over 21,000,000 tons. In 1900, 277 commercial mines in 58 counties of North Dakota, Montana, Idaho, Wyoming, Utah, Colorado, and New Mexico, produced 13,496,555 short tons, worth a little over $17,400,000. Of this total coal product, 35 per cent was used for railroad fuel, 28 per

cent for manufacturing fuel, 27 per cent for domestic fuel, and 9 per cent was made into coke.

THE ALCHEMY OF HOAR-FROST.*

By ARTHUR H. BELL.

COOLED surfaces are nature's plates, upon which she etches some of her most beautiful pictures. In this artistic work she employs many materials, but her choicest effects are obtained through the medium of hoar-frost. Commonly, hoar-frost is described as being merely frozen moisture, but this is not an adequate description of an agent that has the power of adorning in a few hours such prosaic objects as gate-posts and dust-bins with all the trappings of fairyland. Moisture is indeed the fabric out of which all this feathery whiteness is built up, but, although it seems sometimes as if it is distributed in a very capricious manner, there are nevertheless certain definite circumstances which cause the hoar-frost to settle down on some surfaces rather than on others.

On any cold and frosty morning it will usually be found that those surfaces that are the best radiators of heat are also those that are most successful in collecting hoar-frost. It is not always realized, however, that all objects are continually radiating heat, so that no matter how much they may receive from the sun, they are constantly trying to get rid of it. A fern leaf, or a stone, may perhaps receive generous supplies of heat during the day, but as soon as night comes it hurries to spend or radiate it, and the object that is quickest at this work will the soonest become covered with hoar-frost. Everyone has observed how the moisture from the air will settle on the outside of a glass of cold water brought suddenly into a warm room. A similar process takes place in the open air, so that as the currents of moist air travel across surfaces that are very cold they pay tribute in drops of vapor, which in warm weather take the form of dew, and in cold of hoar-frost. Moisture, therefore, plays a very important part in the development of these hoar-frost pictures; but there must not be too much of it. Some of the most delicate designs occur during the prevalence of mist and haze, and in towns especially it is no uncommon thing for a choking brumous fog to be in some degree compensated for by a subsequent display of copious hoar-frost. As regards discovering what kind of surfaces are best adapted for collecting hoar-frost it may, in passing, be said that a very instructive and entertaining series of observations may be obtained by exposing to the frost cups, dishes, tumblers, saucers and other glass and china ware, which will be found to accumulate hoar-frost in a varying degree. A brief contemplation of these differences will clearly demonstrate the fact that it is those objects that cool the quickest that make the speediest responses to the alchemy of frost.

In certain parts of the world agriculturists protect their crops from damage by frost by setting light to heaps of rubbish, thus producing clouds of smoke, which check the radiation of heat from the surface of the ground. By this means frosts are warded off and the life of susceptible plants is prolonged. A similar thing happens when real clouds float overhead, it being a common experience that no dew or hoar-frost forms when the night is cloudy. In other words, a canopy of clouds acts toward the earth as an overcoat and prevents the loss of the heat which it received from the sun during the day; for no sooner does this heat attempt to escape into space than the clouds reflect it earthward again, and they form indeed a veritable trap for sunbeams. But when the air is damp and the stars are shining brightly, the thermometer at the same time being ten or more degrees below the freezing point, everything will be dusted over with fragile flowers of frost, and more especially if there happens to be little or no wind.

During very many years it has been a popular superstition that it is injurious to sleep with the moon shining on one's head. From what has already been said as to the way in which moisture promptly settles on all objects that are radiating their heat quickly, it will be gathered that it is not so much the moonbeams that work the mischief as the loss of warmth and the deposition of moisture which falls on all surfaces exposed to the sky on cold and cloudless nights, when dew and hoar-frost are most abundant.

It is, further, not commonly realized that the atmosphere acts as regards moisture very like a sponge. According to this conception of the case the air is not only able to absorb large quantities of water, but it is also able to retain it; and it is only when something happens to squeeze the atmosphere, as the process may be termed, that the hold on this moisture is relinquished. This squeezing of the atmosphere takes place whenever there is a fall in temperature, this being the great agent or force that precipitates the moisture from the air and causes it to take the form of rain, hail, snow, fog, dew, or hoar-frost; these various forms being regulated by the conditions of the atmosphere. Although the air parts so readily with its stores of moisture when the temperature falls, it is to be observed that an increase of temperature greatly enlarges its capacity for moisture. A cubic foot of air having a temperature of 32 deg. can accommodate only 2.13 grains of moisture; but supposing the temperature to be increased to 72 deg. there would then be room for 8.47 grains. It will therefore readily be understood that in looking out for copious displays of hoar-frost, the best pictures will be observed if during moist weather a body of air having a high temperature is suddenly reduced to the freezing point.

One of the best ways of keeping a jar of water cool is to wrap a damp cloth round it; the evaporation of the moisture producing loss of heat. In hot climates this circumstance is, indeed, made of practical service as regards the manufacture of ice, for so intense is nocturnal evaporation of moisture, that it is found that if water is placed in shallow porous pans overnight, there is a welcome supply of ice in the morning. When, therefore, moisture is evaporating into the atmosphere there is always a loss of heat, so that the greater the amount of vapor passing into the air the greater the amount of heat used up.

It is an interesting fact that when hoar-frost, or dew, or any of the other children of aqueous vapor, spring into being, this heat reappears, or as it is sometimes conveniently described, latent heat is set free. As regards rainfall the amount of heat liberated is, of course, greater than is the case with hoar-frost. A fall of one inch of rain means that over every acre of ground a weight of one hundred tons of water has fallen, or 60,000 tons to the square mile. Put in another way, this downpour over such a well-known area as the Thames Valley means that 53,000,000,000 gallons of water have been precipitated from the atmosphere. It has been calculated that the condensation of one gallon of rain gives out enough latent heat to melt 75 pounds of ice, or to melt 45 pounds of cast iron. From these figures the mathematically inclined may work out for themselves the amount of heat set free in some tropical downpour when the rain instead of being an inch in depth, is seven or eight. That this liberated heat has great effect on the temperature and movements of the air goes without saying, but this part of the subject must not here be further pursued. It is now sufficient to say that just in the same way that condensing rain gives out heat, so do hoar-frost and dew, and a recognition of this fact has resulted in the suggestion of a rule for foretelling the occurrence of hoar-frost.

The success of this prognostic depends on the fact of there being an intimate relation between the deposition of hoar-frost and the temperature of the dew point, as it is termed. Reference was made above to the circumstance that the amount of moisture a given body of air can hold depends on its temperature. Thus at a temperature of 52 deg. a cubic foot of air is capable of giving accommodation to 4.39 grains of vapor, but at 32 deg. there is room only for 2.13 grains. If, therefore, a body of air at the former temperature is suddenly cooled, its capacity for moisture is correspondingly reduced and some of the aqueous vapor spills over, as it were, or is condensed. From this it will be seen that there is a critical temperature below which any vapor-laden air cannot be reduced without some of the moisture spilling over; this critical temperature being called the dew point. A glass of cold water (to repeat an illustration), when brought into a warm room, reduces the temperature of the air in contact with it to the dew point, so that drops of moisture form on the outside of the glass. Instruments that give the temperature to which the air is thus reduced are called hygrometers, and during frosty weather, as already suggested, a knowledge of this dew point may become exceedingly useful.

If, for instance, in the evening, the hygrometer shows the dew point to be above 32 deg., in the majority of cases there will be no hoar-frost that night. On the other hand, if the dew point is below 32 deg., and if there is a moderate amount of moisture in the air, plenty of hoar-frost may be expected. From what has previously been said it will be seen that this prognostic is capable of a very simple explanation. Latent heat is set free when condensation of moisture takes place, so that when the dew point is above 32 deg., any deposition of moisture results in a little warmth appearing, which is often quite sufficient to ward off hoar-frost. On the other hand, with a dew point below 32 deg., these hidden stores of heat are not sufficient to hold in check the advance of the icy spicules.

But probably the most interesting fact in connection with hoar-frost is its growth, it being no uncommon thing to see favorable surfaces literally submerged in a frosty mantle. Hoar-frost, moreover, is better suited by an atmosphere where moisture is plentiful than when it is not so abundant, these latter conditions being more favorable for the birth of dew-drops. Another consideration is that moisture may be reduced below the freezing point without congealing. It is a common experiment thus to treat moisture, although the slightest shaking of this cooled liquid is enough to change it promptly to a solid form. Similarly as regards the moisture in the atmosphere, there are excellent reasons for supposing that in certain circumstances the vapor may be a degree or two below the freezing point without actually solidifying, and is only waiting the touch that will turn it into a feathery frond of ice. Supposing, then, that moist air in this condition is gently wafted against a bush, a fence, or a blade of grass, the shock, though slight, is quite enough to work a magical transformation. The greater part of these frost effects are thus prepared in the air, and as each body of chilled vapor floats against an object having already upon it a covering of frost, it is, as it were, roused by the shock, and awakening, promptly adds its load of frozen crystals to the growing picture.

* Knowledge.

HOW ANIMALS FIGHT.

THERE are no wild beasts in Europe suitable for the combats which Orientals love, or they would certainly have been utilized. Wolves look very promising, and it might be thought that such an ill-tempered animal as the Russian bear could easily be roused to fight a comrade; but we may be sure that the experiment was tried often enough to prove that in neither case was it worth while to make a match. So our forefathers had to be content with the hideous sport of "baiting" —which is not our theme. Had they possessed more ingenuity, however, some diversion might have been obtained from stags. Even antelopes are used in India, though they need training. It is their nature to fight only at the rutting season; to make them eager for the fray at any time they must receive special treatment, and above all they must be kept in practice. But that means a great "consumption" of antelopes, for they battle to the death, and this variety of entertainment, therefore, is not common. Elephants and tigers are the favorite victims, of course; but nothing profitable can be said about their duels and certainly nothing amusing.

A camel fight is rather curious. The brutes have a pair of teeth far back in the jaw, which rival those of a tiger, and an old male is extremely ferocious. Knowing, however, that these, their most terrible weapons, are useless in a front attack—for, vast as the camel's gape is, it cannot be stretched wide enough to bring them into action—they never try to grip the head or neck or any vital part of an antagonist. All their strategy is directed to the object of seizing one of his legs below the knee, and thus overthrowing him by pressure; then the huge back teeth can be brought to bear upon his throat, and he is no better than a corpse. There are those who deny that the camel has any sense at all, and they appeal to everybody who knows the beast by experience. But the rule laid down by Pope is justified in this instance also—

"Its proper power to hurt each creature feels,
Bulls push their horns and asses lift their heels."

The camel's way of fighting is mean and awkward—the *coup de Jarnac* of quadrupeds. But it is the one best suited to its anatomy. A very strong stomach, however, and a nose which has lost the sense of smell are required to enjoy this spectacle.

Of all combats between beasts, perhaps that between a horse and a tiger is the most thrilling. We have read several descriptions, and always, if we remember right, the horse was the victor. But it must be a stallion, as cunning as brave. To avoid the tiger's spring, in a walled area of limited extent, is impossible. The horse does not try; it is only careful to face the enemy, turning on the same spot as he circles round. At length the spring is made; it sinks its forequarters till the knees almost touch the ground, and the tiger lights, unsteadily, upon its haunches. Instantly the hind legs lash out, with such force that the brute is thrown headlong, and if it does not recover its feet in a second the battle is over, so rapid and so heavy are the kicks bestowed. In general, however, there is another "round" exactly similar, and the tiger confesses itself beaten.

Such a match, like a fight of camels, has some interest; but the "hammer and tongs" struggle between two elephants, or an elephant and a rhinoceros, must be always as dull in reality as in description. Lions and tigers are not much more scientific in their methods. Oriental ingenuity, however, has devised some eccentricities in this line. The old Greeks loved a quail fight, and the sport is to be witnessed occasionally in southern Europe. Partridges are used in India. That curious book, "The Private Life of an Eastern King," which made a stir in our grandfathers' time, gives a lively account of the diversion as practised at the Court of Oude. When the table was cleared every evening after dinner two cock partridges were introduced. They trotted about, comfortably and friendly, being familiar with man, until a hen dropped between them.

There is a fable of Lafontaine's, loved by French children, which begins, "*Deux coqs vivaient en paix—advint une poule,*" etc. Its truth to nature was demonstrated by the conduct of those partridges, hitherto friendly, which ruffled their feathers, crowed, and engaged upon the spot. The king would have half-a-dozen "mains" before adjourning for more sophisticated amusements in the "drawing-room." Crows were substituted for the partridges sometimes, but the stupid chronicler only mentions this without giving any details of the proceedings. A crow fight should be droll. But "they went one better" in Manipur. Before the war, while the Maharajah and his noble kin spent all their time in diversion, and employed the public revenue for that object only, the aristocratic sports were polo and pigeon-fighting. The latter does not seem to promise much amusement; but very few of us can judge, for who in this country has seen two doves in mortal combat? Somehow the nobles of Manipur contrived to get up a match, and they found it quite desperately exciting.

Common pigeons there, such as nature designs for pies, fetched three halfpence apiece, while a proved specimen of the warrior class was valued at £3 or £4. But how they bore themselves in fight is a mystery. Mrs. Grimwood often saw a match as she passed along the streets near the palace, but she could never understand how it was going. The birds beat each other with their wings, cooing loudly, and presently the victor was acclaimed—for no apparent reason. But the excitement of the owners and spectators was intense—the betting furious. When Princes of the blood, who were a multitude, lost more than they could pay, as a matter of course, they drew upon the Maharajah. His patience gave way at last, and edict forbade any of the royal line to engage in a sport of such fatal fascination. But a bird almost more unlikely than the pigeon has been induced to fight. Sir Hope Grant witnessed a battle of nightingales or bulbuls, and he says too briefly that "It was amusing enough in its way."

The horse fights of the Northmen must not be overlooked. It was a sport not unworthy of them, for they took part in it themselves, and risked their lives. The owner or a friend attended his stallion to the fray, carrying a short stick, with which he hit it at the psychological moment—that is, at the crisis of the battle. Anyone who has seen well-bred fighting will understand that this would be a service of great danger, the stick being short. But also it was the duty of the champion to "assist" his horse when it rose on its hind legs to attack.

How he assisted it, we cannot tell, but evidently he must have been quite close—sometimes, no doubt, between the furious brutes. Besides these obvious risks, there was a strong probability that he might strike his antagonist's horse, or even the antagonist himself, and, whether this were done by accident or by an impulse of passion, signified little. In either case the blow must be avenged, unless the rivals were personal friends. A certain Eygulf hit his own stallion, and the stick, rebounding, touched Bjarni's shoulder—showing, by the way, how very close they must have been, horses and men, in the heat of the fray.

He instantly apologized, offering sixty sheep if Bjarni would overlook the accident, and the latter replied that it was his own fault; for there was no ill-feeling between them. But, of course, he expected the sheep. In due time Eygulf looked them out, and Bjarni came to receive them. Thermod, Eygulf's father, was present, and remarked, quite mildly, as we should think, that sixty sheep were a "lot." Actually no more than that—but Bjarni struck him dead. A blood feud followed. But if a charge of foul play were made, and the parties concerned were men of influence, all the people of each district would take sides. Odd, "an overbearing fellow," struck Gretti, who, diving under his horse, which was on its hind legs, delivered such a thrust that he knocked Odd into the river,

breaking three of his ribs. The result was a small civil war. Thus, horse fights often ended in man fights. But that possibly gave further attraction to the sport.

TURBINE ENGINES FOR PASSENGER SHIPS.—NOTES ON THE "KING EDWARD." *

Turbine engines for passenger ships cannot now be fairly classed among the novelties of engineering. In these days of keen competition, the development of novelties and the application of novel principles are rushed ahead at full pressure, and when measured by progress made it seems now a long time since the "Turbinia," the first of the turbine steamers, startled the engineering world with a speed of 34½ knots per hour. That 34½-knot gait was raised in a subsequent vessel to 37, but still the bulk of engineers engaged in the production of ships designed for earning money took but an outside interest in the development. For warships of the destroyer class the absolute maximum of possible speed is the first thing to be desired, and the expenditure necessary to secure the extra space is a matter of comparatively small importance. In trading steamers, especially in those engaged in passenger traffic, speed is certainly desirable, but it is of importance that it should be accomplished with a due regard for economy. The desire of owners to possess fast boats is still held strictly subservient to the stronger desire that every ship in the fleet shall show a profit, and the turbine, in its early career, had the reputation of being a gluttonous devourer of coal.

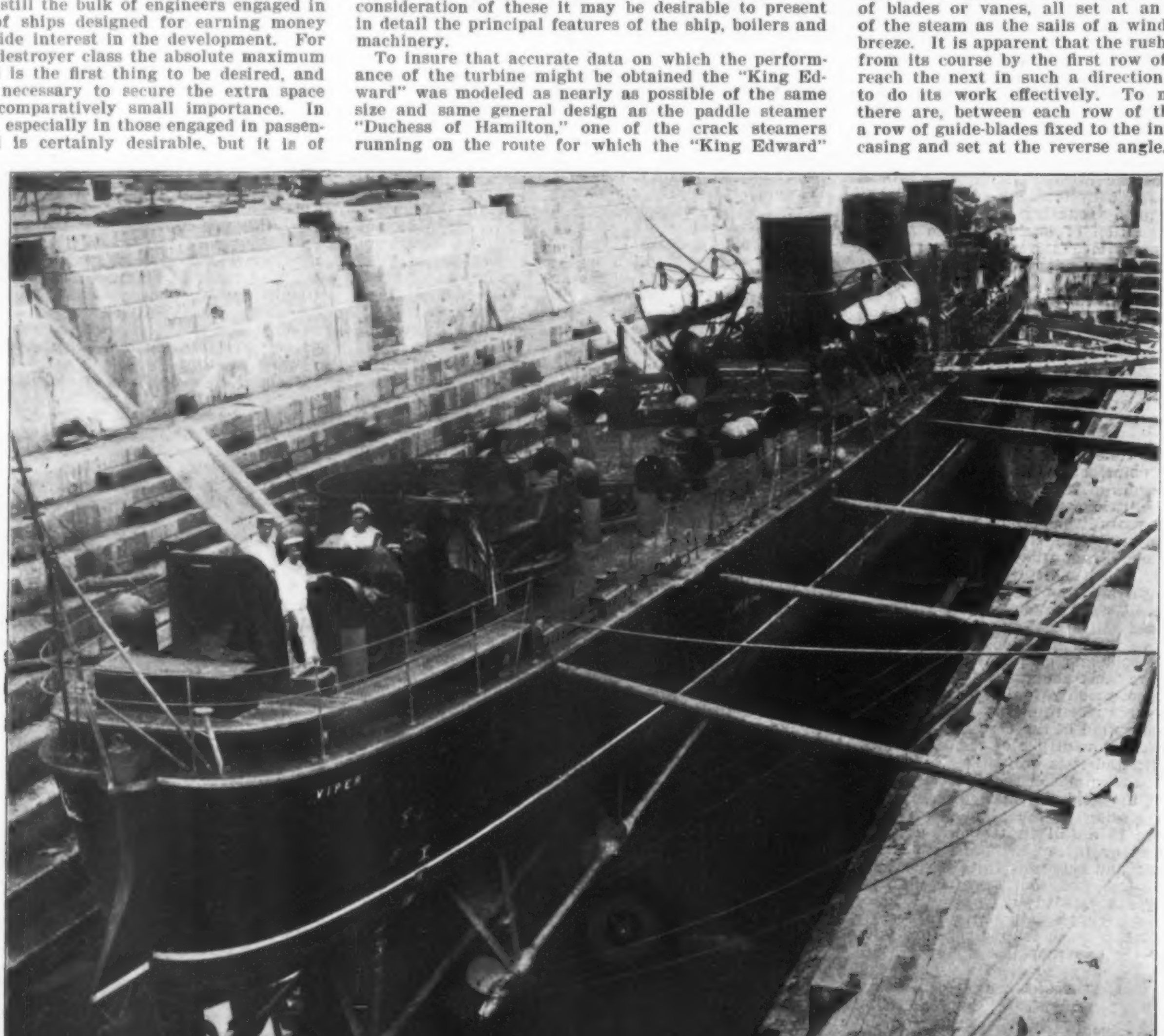
So the experimenting was left to the inventor, the Hon. Charles A. Parsons, of Newcastle-on-Tyne, and the British Admiralty. A new era was, however, opened when the inventor declared his belief that the improved turbine was capable of entering into competition, on profit-earning ships, with engines of the reciprocating type. The assertion was received with some skepticism, for the turbine had still its old reputation for extravagance. To prove it the "King Edward," a passenger steamer of a type in common use on the Clyde, was built early last year by Messrs. Denny & Company, of Dumbarton, Scotland. The builders, the Parsons Turbine Company, Ltd., and a captain of long experience in the Clyde passenger trade and the steamers by which it is carried, were all equally interested in the venture. The results of a long and hard season's work give valuable data for judging the accuracy of the claim put forward; but before proceeding to the consideration of these it may be desirable to present in detail the principal features of the ship, boilers and machinery.

To insure that accurate data on which the performance of the turbine might be obtained the "King Edward" was modeled as nearly as possible of the same size and same general design as the paddle steamer "Duchess of Hamilton," one of the crack steamers running on the route for which the "King Edward" was designed. The latter is, however, of slightly greater draught and more displacement. She is also a little finer forward, and has a remarkably easy delivery. The weight of the motors, condensers, steam pipes, auxiliaries connected with the propelling machinery, shafting, propellers, etc., is 66 tons; which works out at about half the weight per indicated horse power of the engines required for paddle steamers of the same type. Another advantage secured to the boat by the adoption of the turbine engines is that increased deck space is left available for passengers. This fact receives recognition in the Board of Trade certificate and is of assistance to the ship as a profit earner.

Steam is raised in a double-ended Scotch boiler of the ordinary type, 20 feet long by 16 feet 6 inches in diameter. There are four furnaces at each end, made to work under forced draught with closed stokehold. For purposes of comparison the capacity of the boiler under these conditions might be set down roughly at about 3,000 indicated horse power.

It is, however, in the steam turbine—the first engine to realize the dream of a perfect steam-driven rotary engine—that the chief interest in the craft is centered. The principle of the turbine is fortunately simple enough to make it easy of explanation. Inside the cylinder to which the steam from the boiler is led is a drum or hollow shaft studded with row upon row of blades or vanes, all set at an angle to the flow of the steam as the sails of a windmill are set to the breeze. It is apparent that the rush of steam, deflected from its course by the first row of blades, would not reach the next in such a direction as would allow it to do its work effectively. To meet this difficulty there are, between each row of the working blades, a row of guide-blades fixed to the inside of the cylinder casing and set at the reverse angle. These blades are stationary, and their sole purpose is to again alter the direction of the flow of steam and bring it back to the straight course from end to end of the cylinder before it meets the next succeeding row of working blades. The tops of the revolving blades reach nearly to the outer casing of the cylinder, and the stationary blades project inward until they almost scrape the revolving shaft or drum. A series of turbine wheels on one shaft are thus constituted, each one complete in itself, like a parallel-flow water turbine; but, unlike

THE STEAM TURBINES OF THE 35¼-KNOT DESTROYER "VIPER." MAXIMUM INDICATED HORSE POWER, 11,000.



TORPEDO BOAT "VIPER" IN DRY DOCK, SHOWING ARRANGEMENT OF THE EIGHT PROPELLERS.

Length, 210 feet. Beam, 21 feet. Displacement, 380 tons. Horse power, 12,300. Speed, 37.1 knots.

* By the Glasgow Correspondent of the Scientific American.

a water turbine, the steam, after performing its work in each turbine, passes on to the next, preserving its longitudinal velocity without shock, gradually falling in pressure on passing through each row of blades, and gradually expanding. There is no rubbing friction and no wearing parts except the bearings on which the main shaft or drum revolves.

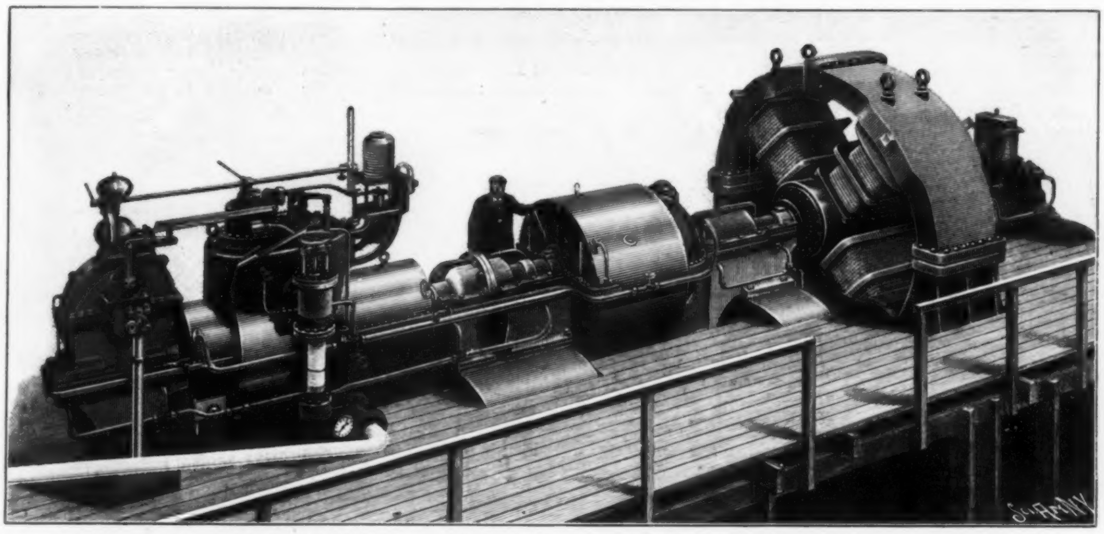
Early experiments proved that such an engine was only efficient when run at a very high rate of speed, and the first use to which it was put by the inventor was for the direct driving of high-speed dynamos.

center shaft is 700 and of the two outer shafts 1,000 per minute. When coming alongside a pier or jetty, or maneuvering in or out of harbor the outer shafts only are used, and the steam is admitted by suitable valves directly to the low-pressure motors, or into the reversing motors for going ahead or astern, on each side of the vessel. The high-pressure motor under these conditions revolves idly, its steam admission valve being closed, and its connection with the low-pressure turbines being also cut off by non-return valves. By this arrangement great maneuvering power is obtained.

with care and thoroughness. The results may be summarized in the following table:

	"Duchess of Hamilton."	"King Edward."
Coal	1,758 tons 13 cwt.	1,429 tons 16 cwt.
Mileage	15,604	12,116
Miles per ton	08.87	8.47
Number of days run	111	79
Daily average consumption.	15 tons 17 cwt.	18 tons 2 cwt.
Average speed	16⅛ knots	18½ knots.

In estimating the value of these figures it is import-



PARSONS STEAM TURBINE AND 1,000-K.W. ALTERNATOR AT ELBERFELD, GERMANY.

Steam consumption on test equivalent to 11.9 pounds per indicated horse power per hour.

The first practical application of the new engine was made in 1884, when a compound steam turbine engine of 10 horse power and a modified high-speed dynamo were designed and built for a working speed of 18,000 revolutions per minute. This machine proved successful, and after doing good work for some years is now preserved in the South Kensington Museum. Other developments on the same line followed, and then the experiments in marine work with turbine engines were started with the famous "Turbinia." Many difficulties were met with, and when these had been overcome the next step was toward adapting the turbine marine engines to ordinary commercial uses. The fitting of the "King Edward" was the first application of the turbine to these uses, and the adaptations necessary are thus described by the inventor in a paper read to Institution of Shipbuilders and Engineers in Scotland.

The machinery, he said, consists of three separate turbines driving three screw shafts. The high-pressure turbine is placed on the center shaft, and the two low-pressure turbines each drive one of the outer shafts. Inside the exhaust ends of each of the latter are placed

The main air pumps are compound, and are worked by worm gearing from the main engines in the usual way. There are also small auxiliary air-pumps worked from the circulation engines for draining the condensers before starting. The other auxiliary machinery is as usual in vessels with reciprocating engines, and includes a feed-heater fed from the exhaust steam of the auxiliaries, and also when necessary by steam drawn from an intermediate point in the expansion of the main turbines.

When this paper was read the all-important question as to how the engines would compare on coal consumption with those of the piston type was still a matter of conjecture, but in his summing up the inventor claimed for the turbine system of propulsion for fast pleasure steamers and passenger steamers of all classes as compared with vessels fitted with ordinary engines:

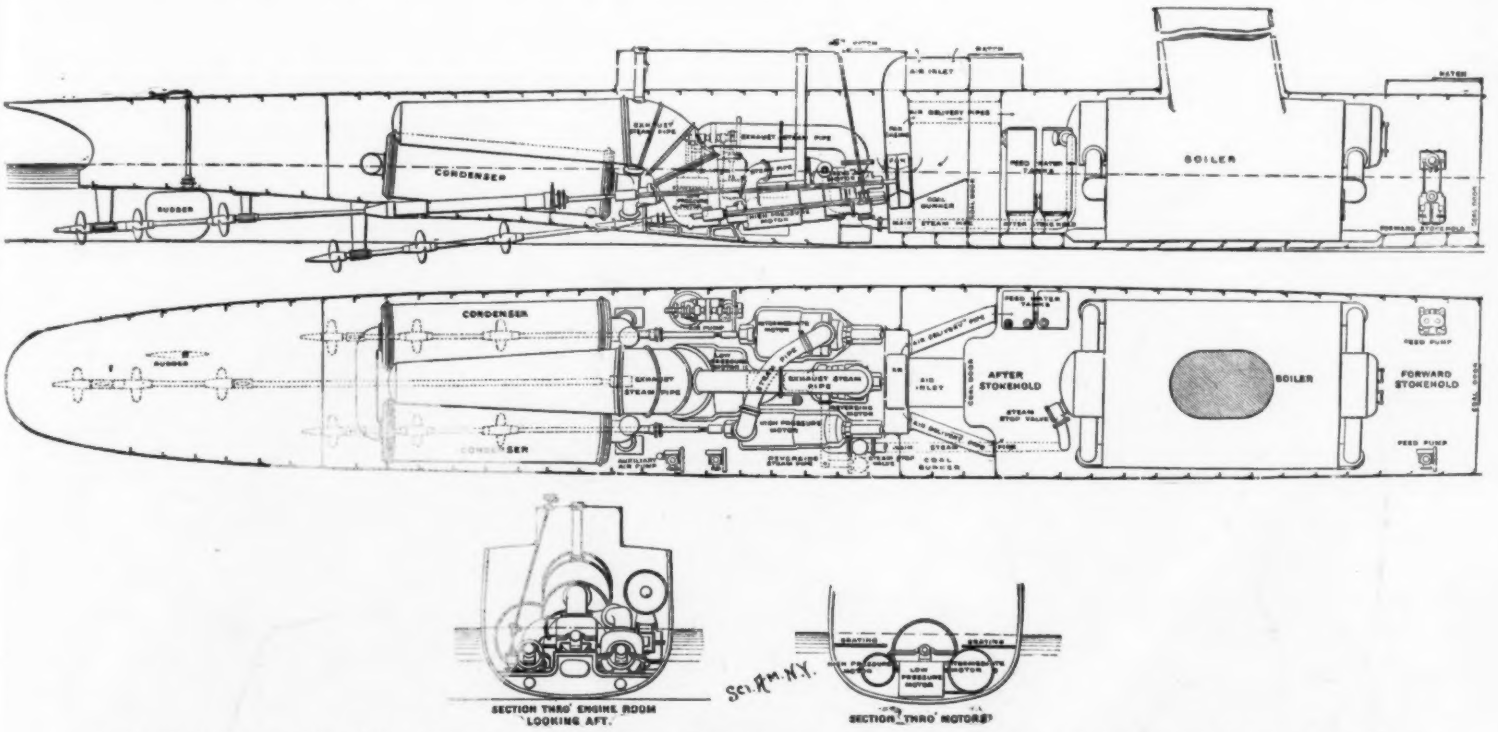
1. Increased speed for the same boiler power, due to considerably reduced weight of machinery, and increased economy in steam. (This advantage increasing with higher powers and speeds.)

1a. Same speed with reduced boiler power and re-

ant that the superior speed of the "King Edward" should be borne in mind. Every engineer knows that it is the knot or two extra that tells on the coal consumption; and to make 8.47 miles per ton of coal at a speed of 18½ knots is a much more handsome performance than to do 8.87 miles at a speed of 16⅛ knots. The test would have been more satisfactory had the length of the season on both steamers been more nearly alike, but the figures, even as they stand, give a distinct triumph for the turbine boat.

The other claims made on behalf of the turbine have been even more fully justified. The absence of vibration was remarked with pleasure by everyone who went aboard, for the engines ran so smoothly that it was only near the taffrail that the slightest shake could be felt. The small size of the propellers kept them immersed in practically all states of the sea, and even when contending against a heavy head swell, the absence of the usual jarring and concussion made the "King Edward" a remarkably comfortable boat to travel on.

As already pointed out, the increased cabin accommodation secured for her a certificate for a greater



SECTIONAL VIEWS OF THE "TURBINIA," SHOWING ARRANGEMENT OF THE TURBINES AND THE NINE PROPELLERS.

the two astern turbines, which are in one with the low-pressure motors, and operate by reversing the direction of rotation of the low-pressure motors and outside shafts.

In ordinary ahead going, the steam from the boilers is admitted to the high-pressure turbine, and after expanding about 5-fold it passes to the low-pressure turbines and is expanded in them to about another 25-fold, and then passes to the condensers, the total expansion ratio being about 125-fold as compared to 8 and 16-fold usual in triple-expansion reciprocating engines. At 20 knots the speed of revolution of the

duced coal consumption for the same reason as paragraph 1.

2. Absence of vibration, giving greater comfort to passengers.

3. Increased cabin accommodation due to smaller machinery space.

4. Less upkeep in machinery and smaller engine-room staff.

From a money-earning point of view the claims made in paragraphs 1 and 1a are undoubtedly those of the first importance, and the tests to which they were submitted for proof or disproof were carried out

number of passengers than would have been granted had the usual amount of space been occupied by the machinery.

In the matter of care and maintenance of machinery she has proved one of the most economical boats ever turned out from Denny's.

Probably the best proof that could be given of the owners' satisfaction with the "King Edward" lies in the fact that they have already arranged to build another vessel of the same type, to be engined also with the Parsons turbine. This craft is now being built at Messrs. Denny's yard at Dumbarton. She will be

20 feet longer than the "King Edward," and will have a speed of 21 knots.

The inevitable deduction from these facts is that the turbine engine is destined to play an important part in the history of the propulsion of steamships where high or moderate speeds are desired, and the further development cannot fail to be of interest to all who watch the struggle for supremacy among the commercial navies.

THE MANUFACTURE AND TECHNICAL USES OF ALCOHOL IN GERMANY.

One of the most interesting and suggestive of the special expositions held in Berlin this year was that of the alcohol industry, which opened on Saturday, February 8, and closed on the 16th of March.

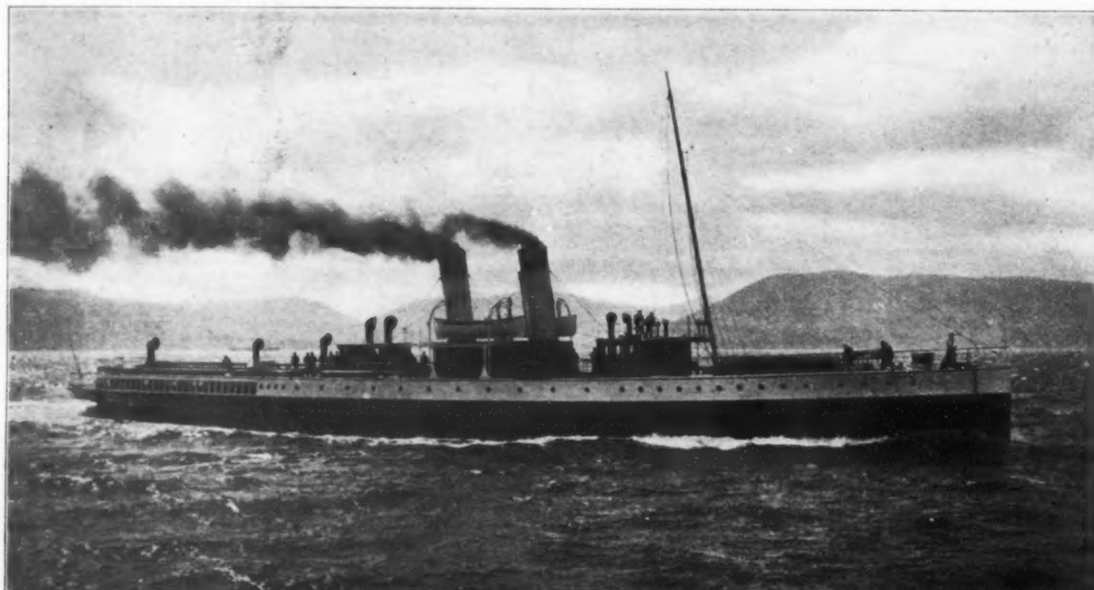
Germany has no natural-gas wells or native-petroleum supply. When, some years ago, the question of adopting motor carriages for military purposes was under discussion it was remarked by the officials of the War Department that kerosene and gasoline engines could only be operated with one or other of the products of petroleum, which is not produced in Germany, and the supply of which might, in case of war, be wholly cut off. But the broad, sandy plains of northern and central Germany—in fact, every agricultural district of the empire—produce in ordinary years cheap and abundant crops of potatoes, from which is easily manufactured, by processes so simple as to be within the capacity of every farmer, a vast quantity of raw alcohol. The crude molasses left as a refuse product of the raw beet-sugar manufacture contains from 40 to 50 per cent of sugar which cannot be crystallized, and this can also be utilized as a material for the production of alcohol. Under these conditions "spiritus," as it is known in Germany, became one of the standard and important products of agriculture, and every effort has been made by the imperial and State governments to promote and extend its use for domestic and industrial purposes. Inventors and scientists have been busy with improvements in the processes and machinery of distilleries. New and highly perfected motors, lamps, and cooking and heating apparatus have been devised and put in use, until crude alcohol is becoming one of the most widely utilized products of German industry. Official statistics show that during the year 1901 there was consumed for technical purposes no less than 116,000,000 liters (30,624,000 gallons) of denaturized alcohol on which no tax was paid. As a concrete result of these conditions, and the pre-eminence of the Germans in every form of applied chemistry, the present exposition is typical, and fairly represents the highest results yet attained in the production and utilization of alcohol. As such, it supplements and largely amplifies in scope the special exposition of spirit engines and motor carriages which was held at Paris from August 16 until November of last year.

GENERAL PLAN OF THE EXPOSITION.

The exhibits were grouped according to their nature under five general categories, viz.: (1) Apparatus for the manufacture of alcohol; (2) motors and motor carriages; (3) illumination by spirit light; (4) heating, cooking, etc., by alcohol flame; and (5) the uses of alcohol in chemistry and the useful arts. They were catalogued under 99 serial numbers, each of which covered the collective display of a manufacturing firm or company.

Of great general interest was the department of spirit motors, which were shown in all forms, upright and horizontal, stationary, portable, and locomotive, and applied to various types of motor carriages. In a lot adjoining the exposition building a circular railway of narrow gage was constructed, upon which trains of ten or a dozen cars were drawn by alcohol locomotives. These were adapted for service on large farms and sugar plantations, and for mining, tunneling, and engineering operations where quantities of earth, stone, or other materials are to be transported short distances. The locomotives are of the vertical-cylinder type, and carry a flywheel to balance and regulate the motion of the engine.

Adjoining the railway was a large open shed in which was exhibited by the Daimler Company at Cannstadt a 10 horse power engineer's wagon, carrying tools and apparatus for a regiment of sappers and miners in field service. Kühlstein & Company, the Berlin carriage makers, exhibited an alcohol-motor wagon and a coupé and runabout propelled by spirit motors, but the display in the department of vehicles fell far short in extent and variety of that in Paris last autumn, which was one of motor carriages only. Owing to stringent police surveillance and many troublesome formalities, automobiles for pleasure and sporting purposes have found thus far a rather lagging and uncertain acceptance in Germany, and in this respect alcohol-motor carriages have shared the general experience. But it is in the class of stationary and portable engines for agricultural and manufacturing purposes that the present exposition was profuse, keenly contested, and instructive. In this class all the leading German gas-engine builders—the Helios, Otto, Körting, the great machine companies of Dresden, Leipzig, and Marienfelde—exhibited their latest and most highly improved creations. These include caloric engines in all forms and sizes, from 1 to 20 horse power, built specially for the consumption of alcohol, as distinguished from oil, benzine, gasoline, or coal-gas engines of established types. Most of them were shown in motion, geared to rotary pumps, circular and band saws, mills for grinding corn, or turning the machinery of distilleries. The Schuckert Company, of Nuremberg, exhibited a 12 horse power military field-lighting wagon, in which a dynamo, driven by a double-cylinder spirit engine, generates electricity for lighting a camp, headquarters, or group of hospitals. It is self-propelled, has a speed of 5 to 10 miles an hour, and should be efficient in actual service. Theoretically, alcohol has only three-fifths of the thermal value of petroleum, but it has been found that for motor purposes 28 per cent of the theoretic energy of alcohol can be utilized against a maximum of 15 per cent in case of petroleum and its products. This advantage in favor of alcohol is still further increased by an admixture of 16 per cent of benzol. Another important advantage of alcohol, which applies specially to its use in motor carriages and in engines for operating creameries and small manufacturing plants in premises adjacent to dwellings, is its absolute cleanliness and freedom from the mephitic odors which render hydrocarbon engines so offensive to many people. At its present price of 15 marks per hectoliter (about $13\frac{1}{2}$ cents per gallon), it competes economically with



THE FIRST PASSENGER TURBINE STEAMER, "EDWARD VII."

THE HIGH-PRESSURE AND ONE OF THE LOW-PRESSURE TURBO-MOTORS OF THE "KING EDWARD."

steam and all other forms of motive energy in engines of less than 20 horse power for threshing, pumping, and all other kinds of farm work, so that a large percentage of the spirit produced in agricultural regions remote from coal fields is consumed in the district where it is grown. The motor for farm use is tightly inclosed and absolutely free from danger of fire.

Next in order of importance are the uses of alcohol as fuel for cooking, heating, and a vast range of scientific and domestic purposes. Accordingly, the present exhibition included a great variety of alcohol stoves for warming and cooking—a large kitchen in operation and accessible to visitors supplied the restaurant which is an indispensable adjunct of a German exposition. There are spirit lamps of all the most improved types for household purposes, as well as for use in chemistry and other scientific processes. One of the neatest of the many new devices shown was a spirit flatiron, handsomely nickel plated and polished, and provided with a small reservoir, which, being filled with alcohol and lighted, heats the iron for two hours' work at a cost of less than 2 cents.

Not less attractive was the department devoted to lamps and lighting apparatus. This is all the product of the past five or six years, and dates from the comparatively recent discovery that alcohol vapor burned in a lamp hooded with a mantle of the Welsbach type produced an incandescent light of intense power. In this special field, alcohol leaves petroleum behind and approaches the illuminative power of electricity. The display in this department included a vast range of portable and fixed lamps and illuminators for all locations and purposes. All are similar in theoretic construction—there is the reservoir filled with spirits from which a wick of multiple strands leads to the burner, hooded with the incandescent mantle and shielded by an Argand chimney. As a measure of efficiency it is claimed for the Phœbus ceiling lamp that it is impervious to wind and weather and gives a light of 85 candle power at a cost of 3 pfennigs (three-fourths of 1 cent) per hour. Another device, called the "Bogenlicht" (arc lamp), yields a light of 550 candle power and claims an advantage of 66 per cent in economy as compared with an electric light of the same radiance under Berlin rates. The ordinary shaded hand lamp for everyday use is typified by the "Piccolo," which is made of bronze, with white or colored porcelain shade, costs from $1.50 to $2.50, according to size and design, and gives a light of 30 candles at a cost for spirit of one-third of 1 cent per hour. This contemplates alcohol for lighting purposes at the present German rate of 25 pfennigs per liter—equivalent to 21.7 cents per gallon. Here, as well as in the departments of power and heating, the cleanliness and unoffensiveness of alcohol as a burning material was most noticeable. Even in the galleries of the exposition building, in which hundreds of engines, lamps, stoves, and other devices were in constant operation, there was no trace of unpleasant odor nor any heat that was oppressive or uncomfortable on a winter day.

The department of chemical preparations included, among many other specialties, solidified alcohol—a brown, translucent mass—which is generally used in small cubes as a convenient form for transportation. It lights readily, can be carried in the pocket, and may be employed as a detergent for cleaning textile fabrics and most other technical uses of alcohol. There is also a large display by several leading makers of vinegar from alcohol and acetic acid. This industry is mainly the growth of the period since 1887, and its extent may be estimated from the fact that there is consumed in this country annually for the manufacture of vinegar 16,000,000 liters (4,224,000 gallons) of alcohol.

The law governing the technical uses of alcohol was enacted in 1887, and, by reason of both its underlying causes and practical results, is worthy of study as an example of intelligent, far-seeing fiscal legislation. It was at that period—about fifteen years ago—that German agriculture began to feel severely the effects of competition from the cheaply grown cereals and meats of the United States, Argentina, and Australia. The landowning class, including the influential nobility—which had been for centuries loyal and steadfast supporters of the Crown—urgently demanded legislation which would save the waning profits of husbandry. Alcohol was a direct secondary product of the sugar manufacture, and could, besides, be made from potatoes, a spring crop which could be planted as a recourse on plowed-up fields of winter-killed wheat and rye. Moreover, alcohol was an indispensable raw material for the chemical industry, and might be made to replace, for certain purposes, the by-products of petroleum. It was accordingly decided to make alcohol for technical uses as cheap as possible, and to promote by all practicable means its production and consumption in this country.

The law was therefore so framed as to maintain the high revenue tax on alcohol intended for drinking, but to exempt from taxation such as should be denaturized and used for industrial purposes. Denaturization is accomplished by mixing with the spirit a small proportion of some foreign substance, which, while not injuring its efficiency for technical uses, renders it unfit for consumption as a beverage. The denaturizing substances employed depend upon the use to which the alcohol is to be subsequently applied. They include pyridin, picolin, benzol, toluol, and xylol, wood vinegar, and several other similar products. As a result of this system Germany produced and used last year 30,642,720 gallons of denaturized spirits, as compared with 10,302,630 gallons used in 1886, the last year before the enactment of the present law. Of this vast amount, about two-thirds was of the ordinary grade for power and heating purposes, such as costs at present 13½ cents per gallon. The remaining third of the entire amount was denaturized for lighting and chemical purposes, or used pure under certain restrictions for the manufacture of perfumes, extracts, and medicinal preparations. The second or higher grade of denaturized spirit, such as is burned in lamps or used for cooking and heating, sells ordinarily for about 25 cents per gallon, but, on account of the enormous potato crop of last year, the heavy production of alcohol, and the stagnation in many industries which are consumers of spirits, the price has been reduced by the national association, or syndicate, of alcohol producers to the equivalent of 21.7 cents per gallon. The wisdom of the system established by the law of 1887 has long ceased to be a question of debate. For every reichsmark of revenue sacrificed by exempting denaturized spirits from taxation the empire and its people have profited ten-fold by the stimulus which has been thereby given to agriculture and the industrial arts.

THREE-PHASE DISTRIBUTION FOR POWER AND LIGHTING.*

By SYDNEY WOODFIELD.

WITH the present knowledge of three-phase working, it appears that its merits for lighting and power distribution are so little known in this country, as for transmission and conversion into either low tension alternating or continuous currents it presents no difficulties whatsoever, but on the other hand, affords a complete solution of the problem of supplying lighting, and within fairly wide limits, power also, for central and outlying districts.

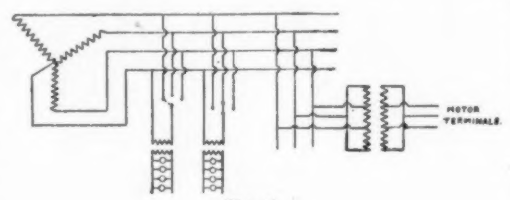


FIG. 1.

Three-phase systems are now being largely put down on the Continent and in America for power and lighting, while in this country high frequency single-phase systems are still put down; such systems are fatal to the commercial success of the undertaking, and in time must be replaced by the polyphase system.

Generators can now be built for 10,000 volts or more in machines of moderate sizes, with a cost of only 6 or 7 per cent more than for machines of half that voltage, the extra cost covering the additional insulation required. A 10,000-volt machine is just as reliable as a 5,000-volt one, as the same factor of safety is allowed in both cases.

In using the higher voltage, however, the cost of cables becomes heavy, for, according to the Board of Trade regulations, the insulation thickness for a 10,000-volt cable must not be less than ½ inch between any conductors, or between conductors and the lead (the B.O.T., however, sanctioned ¼ inch for the Glasgow tramway cables, working at a pressure of 6,500 volts), and as practically all high-tension cables are insulated with impregnated paper, and so require to be lead covered, it will be seen that the lead will cost no inconsiderable amount; adding to this, the large size of ducts required, and the extra cost of laying, the total sum will be a pretty substantial amount.

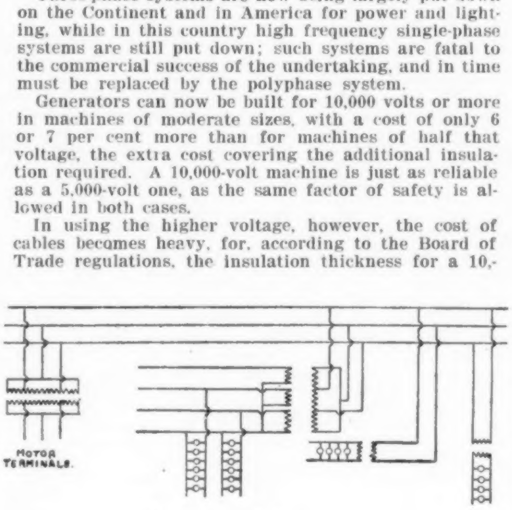


FIG. 2.

It is doubtful whether the Board of Trade would allow any method of laying other than the solid system for this potential, and the author estimates the cost of a 0.1 square inch three-core stranded paper cable, including laying, excavating, troughing, etc., at about 20 shillings per yard.

It is unnecessary to enter into the relative merits of the various frequencies to be used, as each has its own particular sphere, but for lighting and power distribution a frequency of 40 cycles per second may be taken as a good all-round standard.

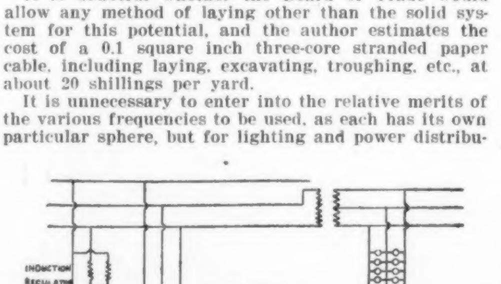


FIG. 3.

The advantage of the three-phase system for distribution for lighting and power lies in the fact that it can be economically used for transmission over considerable distances, and thus a central station can do a large amount of business by supplying power to the outlying factories and mills, and in the supply of small lighting plants in the outlying districts. Another advantage lies in the fact that rotary converters can be operated, and direct current for tramways or light railways can be produced, or direct current may be required for lifts, hoists, etc., or for electrolytic work. The disadvantages of the two-phase system, as compared with the three-phase, taking first the two-phase three-wire system, is that for a definite amount of power to be transmitted at a definite pressure with a given loss, the amount of copper is considerably in excess of that required for the three-phase system under the same conditions, and, moreover, the system on inductive load is very difficult, if not practically impossible to operate.

The two-phase four-wire system possesses similar disadvantages to the two-phase three-wire as regards copper, but for lighting solely is fairly satisfactory, while on inductive load the operation is difficult. It will be seen that such a system must be divided into groups or sets of groups, this division naturally overcoming many advantages, and, moreover, it becomes necessary to control each group by means of an induction regulator, as the load factor of the various groups may be entirely different owing to the peculiarities of the different neighborhoods into which the groups run, consequently, to keep constant pressure adjustment on each group requires careful attention.

With a two-phase generator both groups are of course influenced by the same field, although, as stated above, they are subject to entirely independent variations. In the discussion set forth below it must not be forgotten that a three-phase generator is capable of taking 75 per cent of its rated capacity on one phase with normal heating, and this single-phase load is to all intents and purposes as great as that which could be carried by a machine of equal weight and cost, if it had been specially designed for single-phase work. It might possibly be suggested that the above reduction of output would be sufficient reason for using a balanced two or three-phase system; a little consideration, however, will show that this is not the case, since the cost of direct-coupled generators of the same frequency is practically dependent on the speed. Thus a 500-kilowatt alternator of slow speed costs very little more than a 400-kilowatt alternator, the difference certainly being less than half the proportionate difference of the ratings.

If the generator is connected "star" fashion, and is used as a single-phase machine, two-thirds of the windings are active, and the placing of these active coils is practically the same as would be arranged for, assuming the machine to be designed for single-phase working. In the first system of three-phase distribution for power and lighting the generators are connected "star" fashion, with a fourth wire taken from the neutral point; this system is used by the Chicago Edison Company for the outlying districts of Chicago, and also at Cincinnati, Toledo, etc.

In the Chicago system the potential between line wires is 4,000 volts, and between any line wire and neutral about 2,300 volts. From the station three-phase feeders are run, each capable of supplying 500 kilowatts or more, these long feeders delivering power to areas, say, of a couple of miles in radius; through each of these districts a three-phase 4,000-volt network is carried, suchwise that all consumers may be connected by short single-phase branches tapped off from one outside wire and the neutral. The necessary transformation is done by means of an ordinary transformer wound for 2,300 volts primary and the declared voltage on the secondary; this transformer either supplies an individual customer or a small local three-wire secondary network, the various branches being arranged to give a balance as near as possible. When motors are required to be operated, they may be run from the three-phase mains, "delta" connected transformers preferably being used, or, perhaps, better still, a three-phase transformer, as this would be a very good balancer. It would be advisable (in fact, the Board of Trade requires it) to earth the neutral wire in order that no potential difference other than that for which it is designed should be thrown on the transformer. This system, which is shown in Fig. 1, is so connected together that motors can be operated with practically no effect on the lighting.

The Commonwealth Company, of Chicago, have arranged their feeders so that they can be switched on to either of the three outside wires and the neutral, and any feeder can, if desired, be independently regulated.

Another system which may prove advantageous in certain cases is the four-wire low-tension three-phase system, as shown in Fig. 2.

In this case the primaries of the transformers are connected "delta" fashion, while the secondaries are connected "star" fashion, the netural being carried to the common connection, and the lights being connected between one of the outside wires and the neutral wire; these are balanced as nearly as possible, while motors are connected to "delta" connected transformers across the three-line wires.

It will be found that for the same lamp voltage, this system is more economical than the three-wire direct-current system. If lighting is required outside the four-wire low-tension network, this can be done by running single-phase feeders (as shown on the right of Fig. 2) from one side of the three-phase mains, these various branches being balanced as nearly as possible. It will be found, however, to be better practice to run out large three-phase mains with single-phase branches, these branches being made as short as possible, so that the loss in each is cut down to a minimum. When the system is laid out on the above lines, motors can be operated with little or no effect on the lights, since a single motor would only be a very small part of the load taking current from the network from which it is operated. The above system is in operation at Salt Lake City, Utah.

A third system (Fig. 3) is that of low-tension distribution by the single-phase three-wire system in the central districts of a town or city taken from one side of a three-phase generator, the generator potential being adjusted only as regards the three-wire network and the remaining two phases being used to operate lighting outside the low-tension three-wire network, these feeders being regulated by means of potential regulators, either operated by hand or automatically.

A third wire may be run into these outside districts if there be any demand for power for motors. In this system no regard is paid to balancing the load on the generators, except that the outside lighting is divided approximately between the two phases, which are not used for the three-wire single-phase low-tension network.

The voltage of the outside feeders can always be shown by a suitable compensating voltmeter.

In most towns or cities the greatest load is situated

* The English Electrical Review.

in the central districts, and can thus be run from an interconnected single-phase low-tension system, the regulation being adjusted to give the best results for this district; thus the most important part is the best regulated.

As all motors, whether of the asynchronous or synchronous type, and rotary converters will take their load from the least-used phase, since this phase has the highest potential difference, they will consequently diminish the unbalancing of the generators; they will also disturb the potential of the lighting phase less than it otherwise would be disturbed, if the motors took a large part of their power from that phase. In certain cases, as for instance, where a single-phase system already exists, the two-phase system may be suggested as the only way of using the cables already laid, more especially if these be of the concentric type (concentric cables are out of the question for satisfactory results with three-phase working), but the author would suggest that the excellent results obtained from the three-phase system for power and lighting over considerable areas, and the disadvantages accruing from the two-phase system, would make a careful study of the whole problem necessary, and it will be found that even in the event of having to pull out several miles of concentric cable, the balance will lie with the three-phase system.

As much has been said regarding the use of induction potential regulators, it may not be out of place to give a brief description of this useful piece of apparatus.

An induction regulator is very similar to an induction motor, the primary winding being placed on the movable core, while the secondary is placed on the stationary core; the primary is connected in shunt across the mains, while the secondary is in series with the mains. The potential in each phase of the secondary winding is constant, but, by varying the relative positions of the primary and secondary, the effective voltage of any phase of the secondary can be varied from maximum boosting to zero, and so on to maximum lowering. The coils are former-wound, and insulated in a similar manner to the coils of induction motors. The method of operating is either by hand or by a motor; in the first case, the movable core is rotated by means of a hand-wheel, but when the regulator has to be operated from a distance, a small motor is arranged for driving the core through a suitable gearing.

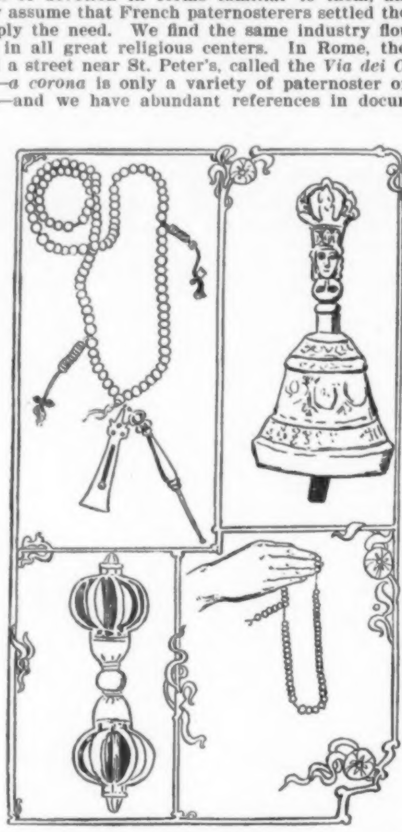
The motor can be either a polyphase or continuous current one, and is controlled by a small double-pole, double-throw switch, thus throwing the switch in one direction lowers the voltage, and vice versa. In order, however, to stop the motor on reaching the limits of regulation when moving in either direction, a limiting switch is provided, which opens the switch automatically. The efficiency of these regulators is somewhat higher than that of an induction motor of the same capacity, but as they have no moving parts to create a draft, they cannot, except in small sizes, be made self-cooling; for the larger sizes they are made for oil or air-blast cooling, depending on which is most convenient for the work on which they are being used.

HISTORY OF THE ROSARY IN ALL COUNTRIES.

By the Rev. Herbert Thurston, S. J.

Although at the present day some justification will seem necessary for inviting the attention of the members of the Society of Arts to such a topic as the History of the Rosary, it would, I think, in the middle ages, have been taken as a matter of course, that there was no organization to which the subject so naturally belonged as that which dealt with the application of the arts to matters utilitarian. As we learn from the elaborate work on the art and craft associations of Paris, compiled by one Stephen Boyleau, as early as the year 1268,* the *Patenôtriers*, the makers of paternosters or rosaries, represented a most thriving industry, which, even at that date, was divided into four different guilds or companies, distinguished seemingly according to the material in which they worked. The first were artists in bone and horn, the second worked in coral and mother-o'-pearl, the third confined themselves to amber and jet, while the fourth were a more miscellaneous association engaged largely in metal work and the manufacture of buttons, buckles and rings.

In England the rosary makers do not seem to have been quite so specialized; and yet, in the London municipal records of the same period, we not infrequently find citizens described as "paternosterers," and there can be no doubt that their trade primarily consisted in the turning, polishing, perforating, and mounting of beads for devotional purposes. We have record, for instance, of an inquest held in 1278, in the reign of Edward I., in the ward corresponding to that now called Farringdon Street Within, at which three of the witnesses were "paternosterers." They were evidently neighbors, and it seems very probable that they all resided in Paternoster Lane, as it was then called, which, you will notice, lay just under the shadow of the great cathedral, and in the devotional center of London. The craftsmen themselves lived in Paternoster Lane, but I am inclined to think that their wares were largely retailed by the persons called "stationers," so styled from the fact that they were allowed to occupy certain "stations," or "pitches," as a modern itinerant vendor would say, around St. Paul's Cross and the cross in the Chepe. The stationers did not content themselves with selling objects of piety, they dealt in all things that were needed by the "clerks" or ecclesiastics, who also naturally congregated around the great cathedral, and were in want of the pens, parchment, ink, copies, and books, i. e., manuscripts, which formed part of the stationer's stock-in-trade. The stationers have clung to their old haunts, and still predominate in the Row, along with the vendors of pious statuary, holy-water stoups, and other such objects. There was also another Paternoster Lane in the 14th century. It lay beside the Thames in the Vintry ward; close to the church thence called the Paternoster Church,† or St. Michael's the Royal. This was the quarter inhabited by the Gascon vintners, who shipped their wines from the town of La Réole, near Bordeaux. It was natural that they should require objects of devotion in forms familiar to them, and we may assume that French paternosterers settled there to supply the need. We find the same industry flourishing in all great religious centers. In Rome, there is still a street near St. Peter's, called the *Via dei Coronari*—*a corona* is only a variety of paternoster or rosary—and we have abundant references in documents



BUDDHIST ROSARY WITH BELL AND "DORJE." MOHAMMEDAN ROSARY.

of the 14th century to the "paternostrari," * who established their booths in the region of the Vatican. Of course, the paternostrari sold many other miscellaneous wares, mostly devotional, besides rosaries, but the very existence of the name in so many different countries shows that the production of these *fila* or *numeralia de Pater Noster*, strings of beads to count the repetitions of the "Our Father" upon, was a matter of commercial importance. Furthermore, as we shall see, the artistic skill spent in the manufacture of some of these articles of piety, and in furthering the spread of the devotion, was often of a very high order. But before we can deal with the artistic aspects of the subject, we have to travel a very long way back to times and places far remote, for it would be a great mistake to suppose that the use of beads or counting prayers was peculiar to the Catholic Church, or was only of comparatively modern date.

In more than one of the French cathedrals, as for instance, at Rheims, and at Limoges, we may find representations of the Annunciation of our Blessed Lady, in which she is shown devoutly telling her beads as the angel salutes her. To Catholics at the present day who only use beads to help them in counting their Aves, that is to say, Hail Mary's, the rosary in our Lady's hand seems a grotesque example of the mediæval disregard of historical verisimilitude, but the detail is not so entirely without excuse as might appear at first sight. After all, the use of rosaries was a practice common to many Oriental races long before the coming of our Lord, and although I know no evidence of its occurrence among the Jewish people, there seems to be, at least, a trace of its appearance in Babylonia, with which, of course, since the captivity, the Jews maintained considerable intercourse. Sir Austin Layard, in his "Monuments of Nineveh," has figured a bas-relief which, according to the description appended to the plate, represents "two winged females standing before the sacred tree in an attitude of worship; they raise the extended right hand, and carry a garland or rosary in their left." My friend, Father Strassmaier, who speaks with authority on such matters, tells me that he is not entirely satisfied as to the meaning of the circlet seen in the picture, and that he is not acquainted with any confirmatory evidence which would establish the use of prayer-beads among the Assyrians; but the details of the bas-relief are highly suggestive of an attempt to represent some act of devotion, and the interpretation of the chaplet as a rosary, is at least probable. Without attempting to settle the matter, it may be noted that the carving probably belongs to the eighth or ninth century before Christ.

Passing to the far East, we come across a number of representations of different deities, many of whom, like Brahma, Siva, the Japanese Amida, and the Chinese Kwan Yin, are commonly represented with rosaries in their hands.

It is possible that some of these can claim a more venerable antiquity than 900 B. C., but it is, I understand, by no means easy to determine with any certainty the dates of Brahmanist and Buddhist antiques, and there is also difficulty in distinguishing the necklaces or strings of jewels often looped around the arms, wrists, and shoulders of these statues, and the rosaries proper intended for instruments of devotion. There seems to be no mention of the rosary in the Vedas, and indeed the traces of its first appearance, whether in Brahmanist or Buddhist literature, are said to be vague and unsatisfactory. It was stated by Mr. Taylor, when lecturing here on Oriental rosaries in 1873, that the rosary was obviously in use among the Hindoos long before the introduction of the Buddhist religion; and we may admit that, on the whole, the theory is plausible.

The only allusion to the rosary that I have seen cited from the earlier strata of Oriental literature, is that contained in the following passage from the Buddhist *Forty-two Points of Doctrine*, Article 10:

"The man who in the practice of virtue applies himself to the extirpation of all his vices is like one who is rolling between his fingers the beads of the chaplet. If he continues taking hold of them one by one, he arrives speedily at the end. By extirpating his bad inclinations one by one, a man arrives thus at perfection." *

Leaving then the question of origins and of priority aside as insoluble with the means at our command, we may turn to gather a few details regarding the use of the rosary by Orientals in modern times, and first of all among the Hindoos. Sir Monier Williams, whose acquaintance with the religious aspects of Indian life was most intimate, speaks as follows.

In regard to rosaries, the rosary (*japamala*) used by Saivas (the votaries of Siva) is a simple string of 32 rough berries, or that number doubled, of the Rudraksha-tree (*Elæocarpus Ganitrus*), while that of the Vaishnavas (the followers of Vishnu) is made of the wood of the sacred Tulasi or Tulsi shrub, and generally consists of 108 beads. Such rosaries may be worn as necklaces, though their chief use is to be em-

FRERE GERARS, KNIGHT TEMPLAR, FOUNDER OF VILLERS-LE TEMPLE, A.D 1273.

* "Le Livre des Métiers" (ed. Lespinasse et Bonnardot), Paris, 1879, p. xvi.

† "Liber Custumarum." (Roll's series, p. 749.)

* Armellini, "Chiese di Roma," p. 780 seq.

* Dr. Zerffi, in Journal of the Society of Arts, 1873, p. 409.

ployed as an aid in the repetition of the names and epithets of the deity, or in the recitation of prayers. Occasional varieties in the material and form of these rosaries may be noticed, for example, Saiva ascetics sometimes carry rosaries formed of the teeth of dead bodies (*danta-mala*), or sling serpents round their neck for necklaces. On the other hand, Vaishnava rosaries are occasionally, but rarely, made of lotus-seeds (*Kamalaksha*).*

I am not sure whether all Saiva rosaries consist of

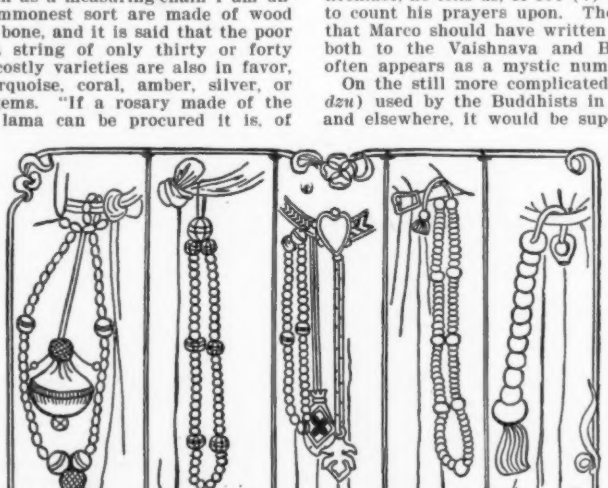
ROSARY OF THE ABBESS MARGUÉRITE AT EPERNAY, A.D. 1351.

32 or 64 beads, but they undoubtedly are made of Rudraksha-berries, also used by certain sects of the Buddhists. These are supposed, according to a Saiva legend, to recall the tears of Siva which he let fall in a rage, and which became concreted into seeds. Their roughness—the surface is almost like a peach-stone—and their five lobes, corresponding to the god's five faces, may possibly have something to do with this selection. The tulsi-beads used by many of the Vaishnava sects, especially those who pay special reverence to Krishna, play an important part in the rite of initiation to which the children are subjected at the age of six or seven. A rosary of 108 little segments is passed round their necks by the priest or the Maharaja, and they are also taught one or other of the sacred formularies used in reciting it.

The operation of counting is considered by the Hindoo ascetic to promote abstraction, a spiritual gift which is greatly prized. But the impression produced on the spectator or auditor by the *nama kirtana* does not always seem to be very ethereal, and Dr. Moore in his "Hindoo Pantheon" asks a little scornfully how devotion can be aided by hearing the names of Krishna repeated thus: "Huri Krishna, Krishna, Krishna, Krishna, Huri, Huri, Huri, Ram; Huri, Ram, Ram; Huri, Huri."

Some curious extravagances also occur in this matter among the Hindoos, and we hear, for instance,† of a rosary suspended from a rafter and consisting of fifteen beads, each as big as a child's head, which as one bead after another was passed through the hands in endless succession must have entailed immense physical fatigue.

That the Buddhists also use rosaries is a fact which many persons, no doubt, will have recently learned for the first time in reading Mr. Kipling's delightful story of "Kim." Whether the rosary of a Buddhist Lama can be used at a pinch as a measuring-chain I am unable to say. The commonest sort are made of wood or pebbles, berries or bone, and it is said that the poor are content to use a string of only thirty or forty beads, but the more costly varieties are also in favor, and are made of turquoise, coral, amber, silver, or even of pearls and gems. "If a rosary made of the bones of some holy lama can be procured it is, of



ROSARIES FROM 15TH CENTURY NORFOLK BRASSES.

course, prized above all others."‡ In China and Japan the beads are often arranged in two rings. There is considerable variety as regards the formula repeated. To judge from the specimens given by Sir Monier Williams, some of the forms are reverent and devotional enough. But whatever form be used, it always concludes with the traditional *Om mani padme hum* (*Om*, the jewel in the lotus, *hail!*).

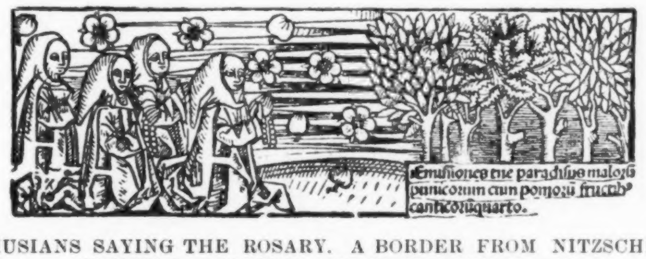
But no modern writer has so fully studied the religious aspects of Buddhism, from within and in its

* Sir Monier Williams, "Thought and Life in India," p. 67.

† The Athenæum, February 9. 1878, p. 189.

‡ Monier Williams, "Buddhism," p 383.

own chosen stronghold, as Mr. L. A. Waddell, who eventually purchased a lamaist temple, and was received by the lamas in virtue of an ancient prophecy as a reflex of the Western Buddha Amitabha. Of the many varieties of rosaries in use among the lamas he gives a very full account. The common and normal type consists of a string of 108 uniform beads, but with two curious appendages, each of ten smaller beads or metal disks, sliding on little cords attached to the main string. These last are called the counters; at the end of one is found a tiny *dorje*, or miniature thunderbolt, at the end of the other counter is a tiny bell;* the extremity also of the rosary itself often has miscellaneous objects attached to it, such as keys, tweezers, etc. These, let me note, present a curious analogy with the signet rings and brooches attached to Christian rosaries in the Middle Ages. The disks or beads on the counters are simply used to keep a



CARTHUSIANS SAYING THE ROSARY. A BORDER FROM NITZSCHEWITZ, "NOVUM B. VIRGINIS ROSARIUM," ZENNA, 1492.

record of the number of times the rosary is said. One counter marks units, the other tens, and the apparatus thus provided is sufficient to register a hundred repetitions of the whole bead-string, i. e., $108 \times 10 \times 10$ mystic formulas in all.

The rosary may be made of precious materials, and when not in use it is wound round the right wrist like a bracelet, or hung round the neck, with the knotted end uppermost. The King of Maabar (Malabar), whom Marco Polo† visited about A. D. 1290, had a necklace, he tells us, of 104 (?) large pearls and rubies to count his prayers upon. There can be little doubt that Marco should have written 108, which is common both to the Vaishnava and Buddhist rosaries, and often appears as a mystic number.

On the still more complicated forms of rosary (*jiudzu*) used by the Buddhists in Japan, as in Burmah, and elsewhere, it would be superfluous to speak; but it is noteworthy that in Japan the commonest type of rosary seems nowadays to consist of 112 beads, though other varieties exist, some of them possessing elaborate provisions for registering a high number of repetitions.‡ Strange to say, from the account of Japan

* "The Buddhism of Tibet," p. 205.

† It is curious to learn from Marco: "And thus did all the kings, his ancestors before him, and they bequeathed the string of pearls to him that he should do the like. The prayer that they say daily consists of these words: *Pacauta, Pacauta, Pacauta* [i. e., *Bhagava* or *Bhagavata* = Lord]. And this they repeat 104 times."

‡ Of the Burmese, Mr. Waddell says that "they seem to use the rosary merely for repeating the names of the Buddha Trinity, viz., Phra or Buddha, Tara or Dhama, and Sangha, and the number of beads in their rosary is a multiple of 3×3, as with the Lamas ($108 = 9 \times 12$). He adds that several Burmese possess a rosary of 72 black subcylindrical beads called Bodhi." (See Journal of the Asiatic Society of Bengal, 1892, pp. 25 and 33.) On Japanese rosaries, see Mr. L. M. James' paper in Transactions of Asiatic Society of Japan, vol. ix, p. 178.

furnished by St. Francis Xavier's native convert, Paul of the Holy Faith, dated 1549, we learn that "the whole nation pray on beads as we do; those who can read use little books, and those who pray on beads say on each bead a prayer twice as long as the paternoster. These strings of beads or rosaries have one hundred and eight beads. They say that their learned men teach that each man has one hundred and eight sorts of sins, and that he must say a prayer against each of these. The prayer is in a tongue not understood by the people as Latin with us."*

But what is of more immediate interest to our present subject is the rosary in use among the Mohammedans called the *subha*, or sometimes *tasbih*, a string of 99, or more strictly, 100 beads, upon which the followers of the Prophet either count salutations, or recite the ninety-nine names or attributes of Allah.

Sir Edwin Arnold, who in his "Light of Asia" has made himself the apologist, if one ought not indeed to say the apostle, of Buddhism, has chosen to pay homage also to the creed of the Prophet in his "Pearls of the Faith, or Islam's Rosary, being the ninety-nine beautiful names of Allah." The ninety-nine beads of the *subha* are divided into three equal portions, sometimes, as in the more ordinary specimens that have been shown me, by a stone or bead of different shape, sometimes, and especially in the more costly varieties, by tassels called *shamsa*, which, made of gold thread and silk of divers colors, have often a very brilliant effect. A hundredth bead of larger size called the Imam, or a tassel in its place, is often added, seemingly to complete the hundred, when the rosary is used for counting *takbir*, *tahlil*, or *tasbih*.

The question, however, which principally interests us in the Mohammedan rosary is the date and manner of its origin. Although little has been written upon the subject, there is a short paper by Prof. Goldziher which, in virtue of the author's exceptional acquaintance with Arabic literature, inspires the fullest confidence. It is admitted, he tells us, that reliable evidence of the use of the rosary among Mohammedans has not hitherto been produced earlier than the 3d century of the Hegira, i. e., the close of the 9th century after Christ, but its use at that time was fully established,† and Dr. Goldziher is tempted to believe the story of the famous rebuke addressed by the Caliph Al-Hadi (c. A. D. 786) to his mother, Chezuran: "It is not a woman's business to meddle in matters of state, get thee back to thy prayers and thy *subha*."‡ As late, however, as the beginning of the 10th century after Christ the use of the rosary seems to have been still looked down upon among Mohammedans as *Bidha*, a novelty hardly worthy of a man of rank and education; for Abu-l-Kasim al-Gunejd (c. 913) was reproached for using it, but replied, as any Christian savant might answer in our own day, "I cannot give up any practice that helps me to draw nearer to God." Even as late as A. D. 1350, the use, or at least the exaggerated use of the rosary was made a subject of reproach as something out of harmony with the primitive simplicity of the Moslem creed.§

But what is specially interesting to us is a series of passages of somewhat uncertain but unquestionably early date, which seems to throw light upon the actual epoch and manner of the first introduction of the new practice. One of these stories, taken from that body of literature known as "Hadith," and the particular collection called "Sunan"—they are assigned to the 10th century after Christ—will serve sufficiently to illustrate the nature of Dr. Goldziher's quotations:

"Certain devout Mohammedans, as he tells us, being met together in conversation, one of them Abu Musa, remarks to his neighbor, 'Formerly O Abd al-Rahmân, I used to see things in the mosques which I could not approve, but now I see nothing but what is edifying.' 'Of what are you speaking?' inquires the other. 'I have seen,' answers Abu Musa, 'people forming circles while awaiting for the moment of the Salat. Each group had a leader to direct them, and they held in their hands a number of little stones. The president said, 'Repeat a hundred *Takbir*' (God is great) and they recited a hundred times the formula of the *Takbir*. Then he told them 'repeat a hundred *Tahlil*' (the ejaculation, 'there is no deity but God') and they recited a hundred times the formula of the *Tahlil*. Finally, he said to them again, 'Say a hundred times the *Tasbih*' ('O, holy God!') and all who formed part of the group carried out what he suggested.' But on hearing this account, Abd al-Rahmân by no means approves of it. At his instance the whole party adjourn to the mosque, and on encountering one of these groups Abd al-Rahmân asked them what they were doing. 'We have a number of little pebbles here,' they replied, 'which we use to count the *Takbir*, the *Tahlil*, and the *Tasbih*, which we keep reciting.' Thereupon, instead of praising them, Abd al-Rahmân delivers a very severe rebuke, in which he bids them count their sins and leave their good deeds to keep count of them-

* Coleridge, "Life of St. Francis Xavier II," p. 214. Mr. James also speaks of the 108 sins or lusts of the flesh.

† Kremer, "Culturgeschichte des Orients," quotes Masudy, viii., 119.

‡ Goldziher in "Revue de l'Histoire des Religions," 1890, vol. xix., p. 295.

§ See Goldziher, op. cit., p. 297.

selves, and reproaches them with trying to know more wisdom than the Prophet, their teacher. 'But, by Allah, O Abd al-Rahmân,' they protest, 'we meant nothing but good.' 'There are many people,' he answers them, 'who mean only good, but who never come at it. They are the same of whom the Prophet says that many read the Koran without its ever getting any further than their gullet.'"*

From this and several more passages of kindred purport, referring to the use of pebbles in counting prayers, Prof. Goldziher is tempted to infer that the custom here spoken of was a sort of primitive *subha*, and was the point of departure for the subsequent development of the Mohammedan rosary. The suggestion seems in every way probable, and the facts must certainly be deemed to throw the gravest doubt upon the assumption almost universally made,† that the Mohammedan bead-chaplet was borrowed full-grown from the Buddhists. It is an assumption for which no evidence is quoted, and beyond the mere fact that beads are threaded on a string, there is no point of resemblance between the two systems.

Of the other principal religions of the world, I do not know any outside the Catholic Church, in which the bead-chaplet is prominent. The word *tschotki*, I believe, in Russian, means a rosary, but the use of such apparatus does not seem to be familiar to the people. Writers have also referred to the *quippos* of the ancient Peruvians; a method of writing by tying knots on cords, as if this also constituted a sort of rosary. But, so far as I can discover, the *quippos* were employed only for calculations, and for recording events, though one form in which pebbles were used, as well as knots, seems, as Father Acosta explains,‡ to have served as a kind of *memoria technica*.

Rosaries, however, are in use among the Copts. They consist most commonly of 41 or 53 beads, and accounts agree in stating that they are employed to number 41 repetitions of the *Kyrie eleison* ("Lord have mercy on us")§ the reiteration of which is also a conspicuous feature in the Coptic liturgy. Whether other prayers are added to these *Kyrie eleisons* does not seem quite clear.

And now, coming at last to the Rosary as used in the Catholic Church, I must begin by expressing my disagreement with the view adopted by Mr. E. B. Tylor and many others, that the devotional exercise was simply imitated from the Mohammedans and introduced into Western Europe through the Crusades. That the suggestion could not possibly have come to Western Europe through the Crusaders, who had, no doubt, many opportunities of watching their Moslem foes piously using their *subha*, would be too much to say. But it is certainly most important to note that the first undoubted mention of the use of beads for counting prayers in the West, to wit, in the instance of the Lady Godiva of Coventry, the wife of Earl Leofric, is anterior by several years to the preaching of the Crusades. The lady bequeathed to the monastery founded by her "a circlet of gems which she had threaded on a string in order that by fingering them one by one as she successively recited her prayers she might not fall short of the exact number."‖ Lady Godiva died before 1070, and this clear and specific statement rests upon what is practically speaking contemporary authority.

But besides this definite evidence of fact, it seems to me that the duty of repeating the same prayer a large number of times, often amounting to more than 100, must inevitably have led spontaneously to the adoption of some contrivance for keeping an accurate record. Not to speak of certain early monks of the desert, it is recorded of St. Godric, an English saint, who died in 1172, that he used pebbles to count his prayers, though we have not the same clear evidence in his case that he strung them on a string, as we have for Lady Godiva. In all the early religious orders, which, like the Carthusians and Cistercians, admitted lay-brothers, the duty of reciting the psalms and lessons of the Divine Office in choir was replaced for the illiterate by that of saying the Lord's Prayer a definite number of times. The number 150, which is that of the Psalms, was regarded in some sense as specially consecrated by tradition. Just as the Psalms were divided into fifties—so much so, that the recitation of two fifties, or three fifties, in Latin, or Irish, or Anglo-Saxon, was a common form of penance¶—so it was natural that fifty "Our Fathers," or twice, or thrice fifty, should be enjoined as a penance or exacted as a suffrage for the dead, from those who could not read. The constitutions of the Knights of St. John, founded in the 12th century, required as we learn from a bull of Pope Lucius III. in 1185, that the knights who were not clerks should say 150 "Our Fathers" each day. Their *paternoster*, which, in this case, was literally employed for the saying the Lord's Prayer only, remained always a part of their equipment. It may be seen in the hands of their Grand Master on the title-page of Caoursin's "History of Rhodes," and it is lavishly used as an ornament upon the tombs of the Knights in St. John's, Valetta.

This duty of reciting the "Our Father" a considerable number of times, and nothing else, in place of the daily office, was practically universal for all monks and religious who had not sufficient education to learn the Latin psalms. Even in the case of the Dominican and Franciscan friars, who were founded at the beginning of the thirteenth century, we hear nothing in their primitive rule about the *Ave Maria*, or "Hail Mary." The Dominican lay-brothers repeated the "Our Father" alone, as their daily prayer of obligation, until the year 1266. It is easy to understand, then, how the strings of beads used for counting came to be called "paternosters." The name still survives in English in the vocabulary of fishermen to denote the number of hooks set at regular intervals along a line, and it seems also to be known in architecture and heraldry. In the sense of prayer-beads it existed in every European language during the middle ages; neither does the primitive signification connecting it with the Lord's Prayer seem to have been entirely lost sight of. I hope to show you a lantern slide of a curious woodcut in the "Speygel der Dogede," a book printed at Lübeck, in 1485, in which Our Lord is represented teaching his disciples the "Our Father," and holding in His hands a pair of rosary beads.* These paternosters were no doubt of very various length, consisting sometimes of 10, sometimes of 50, sometimes of 150 beads, but for the longer varieties, it must obviously have been found a convenience to divide the beads by markers, as is the case in the Oriental rosaries, notably those used by the Mohammedans. This might be done either by introducing a new bead or knot, or token of some kind, at the end of each ten, or by making each tenth bead larger.

One of the earliest representations of a rosary, which I am able to cite, is taken from the incised tombstone of a knight-templar, dated 1273. There can be little doubt that the paternoster he carries was used to count the "Our Fathers," which he was required to say by rule. We find it accurately divided into nines, each tenth bead being a big bead.† Other early paternosters are divided by big beads inserted after every five—again, as I believe, for convenience of counting, and the fact that these larger beads were called in French *seigneaulx* (markers), seems to indicate the purpose for which they were introduced.

And now we pass from the paternoster, properly so called and used only for saying the Lord's Prayer, to the Rosary of our Lady, the only rosary, practically speaking, now used by Catholics, and the one which, by a widely received tradition, is connected with the Founder of the Dominican Order. Of the controversy regarding the origin of this devotion, this would not be the place to speak. I am only attempting here to treat the archæological and artistic side of the subject; but it will be well perhaps to explain, that in this form of prayer, which has also from a very early period been called our Lady's Psalter, the Hail Mary is repeated 150 times—the number of psalms—though for convenience sake, this number is divided into three

GERMAN ROSARIES FROM EARLY 16TH CENTURY BRASSES AT MEISSEN.

sets of fifty. This is the essence of the devotion, and it is thus, so to speak, an imitation for the benefit of the illiterate of the practice of saying the psalter of David by heart or from a book. Each psalm was represented by an *Ave*, and as the monks, who sing office in choir, are encouraged to believe that it is not necessary to follow the exact sequence of thought of the Holy writer, but that their duty of prayer is sufficiently satisfied by meditation on some word or phrase of the psalms, or any pious topic, while the words are sung aloud, so the simple peasant was taught, while saying his tale of *Aves*, to meditate devoutly upon some incident in the life of that Blessed Son whom the Virgin Mother thus saluted had brought into the world. This general feature of 150 salutations to our Blessed Lady, accompanied at least in a vague sense by the recalling to mind of the mysteries of our Redemption constitutes the essence of the devotion and was present I think from the beginning.

It is easy to talk of vain repetitions, but I may perhaps be pardoned for saying here that these do not seem to me more vain or meaningless than many things we are agreed in approving. I think it would surprise those who may have never come into contact with a devout peasantry, how little of superstition, and how much of what is best and truest in Christianity is fostered by the quiet and oft-repeated telling of the beads. In later times, the devotion of the rosary has crystallized into certain set forms. The whole number of 150 *Aves* is divided into fifties, and then again into tens, and between each ten Hail Marys is repeated an Our Father, preceded by the Doxology. This Our Father is represented usually in the string of beads, by a bead of larger size, each decade being thus separated from its neighbors. Moreover, corresponding to each of these decades a definite subject of meditation or "mystery" is set down, the fifteen mysteries being divided into five joyful, five sorrowful, and five glorious, which follow in chronological order. The "five joyful mysteries" are the "Annunciation," "Visitation," "Nativity," "Presentation" and "Finding in the Temple," all of them, of course, scenes in the gospel history which occur repeatedly in mediæval art. The sorrowful mysteries are concerned only with the Passion. They are the "Agony in the Garden," the "Scourging," the "Crowning with Thorns," the "Carrying of the Cross," and the "Crucifixion." The glorious mysteries are the "Resurrection," the "Ascension," the "Descent of the Holy Ghost," the "Assumption of our Lady," and the "Coronation of our Lady in Heaven." This definite arrangement of mysteries, however, is of very late introduction. The earliest book which I know containing precisely these subjects in this exact order is a Spanish volume printed at Seville in 1495.*

A somewhat earlier work, approximating closely to this scheme, and founded on the writings of Alan de Rupe, was first printed at Ulm in 1489;† but in place of the Coronation of Our Lady, "the Last Judgment" is there assigned as the fifth of the glorious mysteries, and is depicted in a woodcut, as we shall see, after a type very familiar in mediæval art.

So far as my researches enable me to judge, all these arrangements of 15 definite mysteries are comparatively late, and do not occur at an earlier date than the last quarter of the fifteenth century. The earlier and more widely accepted practice was to assign an incident of our Lord's life to each of the fifty Hail Marys, and to add some little clause commemorating the incident to the words of the Hail Mary itself. This practice, I venture to think, must have had a considerable influence upon the art of the wood engraver at the time of the Renaissance. With the introduction of printing a very large number of rosary books were produced, meant for the most part as aids to the devout to help them in their meditations. In the more sumptuous of these a different wood-cut is provided for each of the fifty, or, as the case may be, for each of the one hundred and fifty Hail Marys. The range of subjects extended from the conception of Mary to her death and coronation, and included, of course, the whole of the life of Christ. In this way a number of gospel scenes came to be treated which are of very rare occurrence in art at an earlier epoch, and the variety thus introduced must have done something toward the deformalizing and deconventionalizing of the treatment of gospel subjects. One of the most elaborate of such rosary-books is probably that of Herman Nitzschewitz, which was undertaken at the command of the Emperor Frederick III., was printed at the Cistercian Monastery of Zenna, in the diocese of Magdeburg, and dedicated after Frederick's death to the young Maximilian. The woodcuts, of which there are a large number, are often grotesque and extravagant, but they are decidedly interesting to the student of religious art and symbolism. Each Hail Mary is illustrated by a scene from the Gospel, in which is inset a very minute cut, duly described in the letterpress, and referring to some Old Testament "type." Those who are acquainted with the mediæval mystery plays, or with the survival of this ancient institution, still to be witnessed at Ober Ammergau, will remember the prominence everywhere given to these Old Testament "types." No one who habitually recited his rosary after the manner suggested by Nitzschewitz could fail in a short time to acquire a wide acquaintance with all the most striking episodes in the Old and New Testaments.

It would take a great deal too long to give details regarding the many pictorial rosary-books produced in the Netherlands between 1478 and 1535. I will only refer to one of rather late date, which appeared with the same series of 50 woodcuts, not only in Latin and Flemish, but also in English. It was called "The Mystik Sweet Rosary of the Faythful Soule," and was published at Antwerp in 1533 by Martin Keyser, or, as his name appeared in a gallicized form, Martin Lemperour. The woodcuts, though small, are of a high order of merit. But the most famous of rosary-books, one which appeared in a very large number of editions, and which, as I gather from a recent catalogue of Quaritch's, still commands high prices, was probably that of the Dominican Alberto de Castello‡ which was printed at Venice in 1522. Like the others I have mentioned, it supplies a picture for each bead or Hail Mary, but being later in date, it reconciles this arrangement, which the earlier books do not, with the division of the whole rosary into the modern fifteen mysteries. I am rather at a loss to account for the value set upon the book, for its engravings are not very remarkable, but it went through a number of editions, and when the blocks became too worn for further use, a completely new set were engraved on similar lines.

There were many more such books, but we must hurry on; and I have barely time to mention the large engravings destined to commemorate the Rosary§ by Erhart Schön and other artists, or the picture painted by Albert Durer, representing Our Lady of the Rosary with the Pope and Emperor and St. Dominic, a picture destined originally for a confraternity of German merchants residing in Venice, but which is now preserved at Prague. A word, however, must be said of the famous Rosary Tablet at Nuremberg, carved by Veit Stoss, of which a plaster cast is to be found at the South Kensington Museum. With the kind permission of the director, a friend has taken for me an admirable photograph of this cast, which I hope to show on the screen. Unfortunately neither the original at Nuremberg nor the South Kensington reproduction represents

* "Revue de l'Histoire des Religions," xxi., pp. 298-299.

† See for instance, Kremer, "Culturgeschichte," p. 40; Tylor, "Primitive Culture," ii., p. 372.

‡ "Hist. Nat. de las Indias," bk. vi., ch. 9.

§ A. J. Butler, "The Ancient Coptic Churches of Egypt," vol. ii., p. 238.

‖ William of Malmesbury, "Gesta Pontificum," book iv., ch. 2.

¶ See Plummer's note in his edition of Bede, vol. ii., pp. 137-138.

* The phrase "a pair of beads," meaning a rosary, is one of the few terms, which being lost to the language at large, have survived among English Catholics. It is used by Chaucer, and in old English wills it occurs again and again. Formerly a set of anything, whether the number were two or more, was commonly called a pair. We still retain the expression two pair of stairs, meaning two flights of stairs. The biographer of St. Hugh, of Lincoln, speaks of his receiving *duodecim paria literarum*, meaning twelve separate missives.

† Another instance of a rosary so divided, evidently by intention, and not by the carelessness of the lapidary, occurs in the tomb of Lord Beauchamp.

* Gorricio, "Contemplaciones sobre el Rosario."

† "Unser lieben Frauen Psalter." There were many editions of this little work, but in German, at any rate, no earlier text seems known than that of Dinckmut, Ulm, 1489.

‡ "Rosario de la Gloriosa Vergine Maria."

§ The letterpress in some of these prints seems to indicate that they were intended to be framed and hung up in the Chapel of Rosary Confraternities. In the Bodleian Library is a large broad-sheet printed at Memmingen, in 1506, containing a long set of verse directions for the saying of the Rosary.

the complete work. The cross within a circle of 50 roses which forms the center, was originally surrounded with a series of small bas-reliefs corresponding to the clauses or mysteries which the faithful were to meditate upon successively as they repeated the 50 Hail Marys. The series begins with the creation of Adam and Eve, and it ends with the last judgment. Unfortunately six of the bas-reliefs have been removed, and are now at Berlin. Let me add here that an even older and more widely spread subject of meditation when saying the five decades of Hail Marys belonging to the rosary is suggested by the five Sacred Wounds. I say more widely spread because the pictorial representations of these in connection with the rosary are extremely common, whether we consider large sculptures and altar pieces or small engravings. The most frequent type represents a garland of fifty roses divided into tens by five larger roses, upon which last stand embossed the right and left hand, the right and left foot, and finally the pierced heart of Christ representing the wound in His side. German examples are plentiful,* and for an English instance I may refer to a quarrel of stained glass at Raby Castle, which is supposed formerly to have belonged to Whitby Abbey. Numerous little woodcuts, containing the shield of the five wounds, are met with in rosary books, and sometimes we find a rose in the center, with a wounded heart displayed upon it, and the hands and feet in the corners.

I have been amused lately to find that a very much worn block of this kind, which has somehow been used as a tail-piece in one of the works of Francis Bacon, has been claimed as a proof that the printing of his books was in the hands of the Rosicrucian brethren, familiar with his cipher methods. These ciphers, says Mrs. Pott, the foundress of the English Bacon Society, the printers, banded together in a secret society, go on using to this day. It may interest some of my present hearers to learn that on the cover of the Journal of the Society of Arts, June 28, 1895, we may read (in cipher presumably) the following words: "Francis Bacon, Viscount St. Albans, Lord Verulam, Shakespeare, instituted the Society of Arts in London for the good of English Commerce." So at least Mrs. Pott informed the Bacon Society in a paper read before that body and published in their journal shortly afterward.†

But to return from this digression, the garlands of roses which are a conspicuous feature of nearly all these pictures and tablets of the fifteenth century imply, of course, a reference to the now generally accepted name of the devotion, the *Rosary* (*Rosenkranz*) as to which name I have as yet said nothing. To determine at what date it was introduced seems extremely difficult. No clear example of it, as a name, seems to occur before the fifteenth century. The beads themselves bore many appellations, "paternoster" being the commonest, but they were not called rosaries. *Rosarium* is, no doubt, *rosarium* (*sertum*), wreath of roses, the corresponding words "chapelet," "corona," "rosenkranz," "capellina," all convey the idea of garland. At that epoch it was common to an extent which we have now great difficulty in realizing, for both men and women in ordinary life to wear garlands of flowers, and to place such garlands as a mark of respect upon the heads of persons and statues. It would be easy to illustrate this from Chaucer, and the metrical romance writers, whether English or French, but the strongest evidence comes from quite prosaic sources.

The *chappelliers* or makers of head-gear of Paris, as we learn from Boyleau,‡ included not only workers in felt and cotton, but also *chappelliers de fleurs*, whose business it was to make flower garlands for actual wear. Among their statutes, which are drawn up as formally as those of any other trade, it is stated that they are forbidden, under a heavy penalty, to work at their garlands on Sundays, except that while the rose season lasted they might occupy themselves on that day in making rose wreaths, though they were not free to make any other kind. So we find St. Louis, King of France at the same period, passing an ordinance that rose garlands were not to be worn on Fridays. The idea of rose garlands was, therefore, very familiar, and although I am aware that *Rosarium* was not uncommonly used in the sense of what we should call an anthology or collection of choice extracts, I am strongly inclined to believe that its application to the particular devotion now under discussion was mainly due to the wide prevalence of one particular story of a garland which we can trace very much earlier than the word itself in almost every part of the Christian world. The name, it seems to me, must have come from the story, and the story was not, as we should at first be tempted to think, evolved out of the name already pre-existing.

The legend in question, which occurs with slight variations in many of those quaint collections of "Miracles of Our Lady," that were so popular in the Middle Ages, is briefly this: A youth was accustomed to make a wreath of roses or other flowers every day, and to place it upon the head of Our Lady's statue. He became a monk, and in the cloister his occupations no longer permitted him to observe this pious practice. Being much distressed, he asked counsel of an aged priest, who advised him to say 50 *Aves* every evening (in some versions it is 150, in others 25), which would be accepted by Our Lady in lieu of the garland. This the young man faithfully observed, until one day, being upon a journey, he had to pass through a lonely wood where robbers were lying in wait. They were employed in watching him, feeling sure of their prey, when he, unsuspicious of their presence, remembered that his *Aves* were not yet said, and forthwith stopped to say them. Then to their surprise, the robbers saw a most glorious lady stand before him and take one after another from the lips of the kneeling monk, fifty beautiful roses, which she wove into a garland and placed upon her head. The robbers, so the legend tells, conscience-stricken at the vision, were all converted to a better life, and themselves soon after entered the monastery.

* E. g. at the Abbey of St. John Schleswig, at Lübeck, Neukloster, etc. See Zeitschrift für Christliche Kunst, 1900, p. 36.

† Journal of the Bacon Society, September, 1895, p. 120.

‡ Boyleau, "Livre des Métiers," p. 198.

Now this story meets us in every part of Europe at a very early date. Perhaps the earliest clear instance is in a collection of German popular poetry assigned to about the year 1236. Before the end of the same century we find it told by King Alfonso the Wise, King of Castille, in his "Cantigas de Santa Maria." It occurs also in several thirteenth century Latin collections of the miracles. Then in the fourteenth century we find it in Mielot's French prose narrations, and it was also dramatized and is included among the interesting French miracle plays, edited by M. Gaston Paris. In the fifteenth century we meet the story again, with slight variations of detail, told both in Germany and in Spain as the history of the true origin of the rosary, but, most curious of all, we find that it has by that time penetrated into far-off Abyssinia, almost as remote a spot, one might think, as it was then possible for any Christian legend to reach. Among the spoils brought back by Lord Napier's army from Magdala in 1867 were some extremely valuable Æthiopic manuscripts, now in the possession of Lady Meux. They are illustrated with miniatures, and colored gorgeously, but in somewhat barbaric taste. These codices supply important evidence regarding the art of Æthiopia in the early stages of its development. But the contents of the volumes are also interesting. They preserve collections of the miracles of Our Lady, so well known in the West for many centuries before, and among these we meet our legend of the rose garland, unchanged in substance, though now told of a cleric of Rome named Zacharias, the leading details of whose history are elaborately illustrated in the miniatures, as I hope shortly to show you. Whether the use of the rosary itself was familiar in Abyssinia in the fifteenth century, I am unable to say, but the Meux manuscripts prove that it was regarded as a conspicuous adjunct of religious life there a century or two later.

Taking the term rosary, as is usually done, in its wider acceptation, so as to include all forms of praying beads—need I say that the word "bead" itself originally meant a prayer—it is remarkable what very great variety we observe in mediæval rosaries. The rosaries themselves have not been preserved to us. I know of no specimen certainly older than the year 1500, and at an exhibition at Limoges, some few years back, in which an attempt was made to bring together some ancient examples, nothing could be procured which was of earlier date than the sixteenth century. None the less we know them from pictures and especially from the careful and elaborate representations on tombs, as well as from the details given in inventories and wills. Before 1450 sepulchral effigies with rosaries are distinctly scarce. There are many hundreds of drawings of early mediæval tombs in the Gaignières collection at the Bodleian, a collection of drawings made in France long before the havoc wrought by the Revolution. I have found among them only one fourteenth century tomb with a rosary. But in the few extant early examples, whether in this country or abroad, there is the greatest possible variety. Two fourteenth century examples of effigies —one at Bangor, and the other at Worcester—show rosaries divided into sevens or sixes. A figure of a mourner at Warwick (c. 1430) exhibits a rosary in nines. Some early French and German examples are carefully and intentionally divided into fives or sevens, and elsewhere we count 75 beads, or 80 beads, or 40 or 33 often without divisions of any kind. One type of arrangement, consisting of six decades, with a pendant of three extra beads, appears in the fifteenth century, and became very common in the sixteenth and seventeenth, especially in France and at Rome. It was distinctively called the *corona*, and was probably intended to honor the 63 years assigned by legend as the years of Our Lady's mortal life. I attribute to this form the prevalence of the pendant of three small and one large bead seen in nearly all modern specimens. One of the earliest examples I know of a pair of beads exactly agreeing with the modern type, is the Duke of Norfolk's magnificent golden rosary which belonged to Mary Queen of Scots, and which at the present moment is being exhibited at the New Gallery. In the Bangor effigy, which shows 84 small beads divided into sevens by larger beads, three large brooches and what seem to be two rings are also attached to the rosary. One is reminded of Chaucer's "Prioresse":

> "Of smal coral aboute hir arme she bar,
> A peire of bedes, gauded all with grene,
> And thereon heng a broche of gold ful shene,
> On which ther was first write a crowned A,
> And after: *Amor vincit omnia.*"

It is dangerous to begin to quote inventories, the series would be endless. But I note that in the inventory of plate and jewels of Charles V., King of France, in 1380, there are entered 19 rosaries (*patenostres*). These, as regards material, were made of rose-tinted amber, jet, coral with pearls for markers (*seignaulx*), gold beads, rings of gold, blue and white enamel, jet beads with 11 gold *croizettes*, black amber and pearls, coral alternating with beads of silver-gilt, and two instances of gold beads of Damascus work, which were filled with musk. Various objects are also mentioned as suspended from the beads themselves, e. g., cameos, brooches, a stud (*bouton*) or pendant of pearls, five *frezettes* (ruffs?), a little lozenge set with pearls, and on the same rosary a *croizette* of coral and a crucifix of gold. As regards the number of the beads, which is not always mentioned, there are one or two instances in which the normal type, as we should now consider it, of fifty smaller beads, with five larger beads, or five *seignaulx* is specified, but in other cases we find rosaries of 200 gold beads, one of 50 beads with eleven *seignaulx*, one of 62 beads in all, one of 75 beads, and other smaller ones of twelve or less.* So again, in the inventory of the Princes of Orléans-Valois in 1408, we have one rosary of amethysts and jasper with a *bouton* or stud of pearls, another of jet, with nine little bells (*dandins*) of gold, and a jewel with nine pearls as a pendant, and another again of jet, with nine gold *saingnaulx* and a gold figure of St. Christopher attached.†

* Labarte, "Inventaire du Mobilier de Charles V."

† Roman, "Inventaires et Documents des Princes d'Orléans-Valois."

There can, of course, be no doubt that such rosaries were quite as much used for personal adornment as for purposes of devotion, with the result that these objects of piety were not overlooked in the sumptuary laws which strove to check the unbecoming extravagance of the burgher class, especially in Germany. The Police Ordinances of Nuremberg, for instance, in the thirteenth and fourteenth century, forbid the using of paternosters of above a certain value, and give curious and minute instructions as to the manner in which they should be worn. Similarly the Municipal Council of Regensburg, in 1485, among other attempted restrictions on habits of luxury, decreed that no one should possess more than three or four rosaries, and that these should not be of the value of more than ten *gulden*. As three fat oxen could then be purchased for 12 *gulden*, this seems a pretty generous allowance.*

One would like to know a little more about the workmanship expended upon these articles of luxury, but the objects themselves have disappeared, and the guild statutes collected by Boyleau tell us very little on this head. The beads do not seem to have been wired, but simply perforated and strung upon a cord. This, no doubt, accounts in large measure for their complete disappearance. The jewels have simply been released from their cord, and used for necklaces, bracelets and other purposes. An incident in Rabelais lets us know that it was an easy thing for a malicious person to cut the string of a lady's rosary, and to pocket the beads which came tumbling down. The only objects belonging to these mediæval rosaries which have been at all extensively preserved, and which we can now recognize as having served for this purpose, are the marvelous spherical boxwood carvings, which at the end of the fifteenth and the beginning of the sixteenth century were used as pendants to hang from the more sumptuous kind of bead chaplet. These pendants or nuts vary in diameter from one to three or four inches, and the carvings also, though such scenes as the Crucifixion or the Nativity often recur, show much diversity, and are by no means always connected with the "mysteries" of the rosary. Several fine specimens belonged to the Spitzer collection, and M. Arthur Pabst, in a detailed notice of this section, speaks as follows: "A special place in the history of sculpture ought to be reserved for these tiny objects, which are called in French *grains de chapelet*, and which are known in Germany as 'prayer nuts' and 'paternosters.' They belong to that section of devotional art which was so earnestly cultivated by artists at the close of the Middle Ages. These rosary beads carved in boxwood and spherical in shape, are often inclosed in an open-work case, or sometimes with two such cases, one outside the other. The bead opens with a hinge, and displays two hemispheres, in the hollow of which are carved two scenes, generally composed of a large number of figures.

Often we find a flat movable disk separating the two halves, itself covered on both sides with delicate carving. Executed as they are with extraordinary skill, these groups which are often cut in high relief and completely detached from the background are no doubt *tours de force*, and are not free from a certain exaggeration; but for all that, there is much in the attitude and pose of the figures which betrays the hand of the true artist. These carvings are probably of Flemish origin, but they may have been wrought under the influence of masters of North Germany in the fifteenth century. It is quite likely that they all come from a very small number of workshops, and the fashion certainly did not last for more than a hundred years. To judge by the architectural details in the carvings and from other indications, all that are now in existence were probably produced in Flanders between 1475 and 1530. Flemish portraits (there is one, for instance, in the museum at Brussels) of this period sometimes show a decade of beads, at the end of which may be recognized one of these large spherical boxwood nuts. The most magnificent specimen now in existence is probably that in the possession of the Duke of Devonshire, which is said to have belonged to Cardinal Wolsey, and to have been given by him to Henry VIII. In the terminal bead, four inches in diameter, twenty-four different scenes are elaborately carved. Three or four fine specimens are in the Waddesdon collection lately presented to the British Museum, and by the kindness of Mr. Read I have been able to obtain photographs of two, which will be shown on the screen.

There are many other aspects of the subject which invite further discussion, but my paper is already too long and I will take my leave here.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

United States Safes in Brazil.—Fire recently destroyed the establishment of Frank da Costa & Co. in this city. This firm is one of the largest exporters of rubber and other commodities in the Amazon Valley, and there were 43 tons of rubber in the building at the time, of which 28 tons were totally destroyed and 15 tons damaged.

The noteworthy feature of the fire was the fine showing made by American safes. There were in the offices of the company six safes: One English, one German, one French, one Portuguese, and two of American manufacture. These were all placed together in the center of the second floor. After the fire, it was found that the Portuguese safe was a complete wreck, and fell to pieces when touched. Its contents were totally destroyed, and the same was true of the French and German safes. The English safe contained in addition to valuable books and papers, 700 contos in Brazilian currency, equivalent to about $175,000. This safe was opened only after the greatest difficulty, and the money was found in an almost unrecognizable charred and pulpy mass, and the remaining contents were a total loss. There is little hope of re-

* Janssen, "Geschichte des deutschen Volkes," 9th Edition, vol. 1, p. 377. The English Kalender of Shepherdys of 1506, in a catalogue of sins, speaks of the vanity shown—

> "In jewels, rynges, signettis amd ouches,
> In orecyousnesse of gowns, gyrdels and bedis."

covering anything of the money thus damaged by fire and water.

When the American safes were opened, their contents were found perfectly intact—money, books, and papers being little, if any, the worse for the ordeal through which they had passed.

There could not have been a more convincing illustration of the superior quality of the American product than was afforded by this incident, which has given rise to general comment.

Frank da Costa & Co. are about to purchase six new safes, and American producers of these articles would do well to make a bid for the contract. Until this occurrence, there was a popular impression among business men here that there was no safe equal to the English one, and this belief was so firmly established as to make competition on the part of American manufacturers difficult. The incident should establish a market for our safes throughout Brazil, if our manufacturers make the proper efforts to win the trade.—K. K. Kenneday, Consul at Para.

Exhibit of Hydraulics and Navigation at Dusseldorf.—The Department has received from the German embassy, Washington, under date of February 13, 1902, notice of the Exposition of Hydraulics and Navigation to be held at Düsseldorf in connection with the Ninth International Congress of Navigation.

Owing to space and means being limited, the exhibition will, as far as practicable, be restricted to models, plans, printed works, photographs, and tables of general interest. The congress will hold its sessions from June 29 to July 5, 1902. Intending exhibitors are requested to make application as early as possible, sending the announcement of the objects to be exhibited, with their size, to the general secretary, Geheimen Baurath Sympher, Berlin W. 66, Wilhelm Strasse 80, April 1, 1902. Objects to be exhibited are to be sent to, and removed from, the Tonhalle at the expense and risk of the exhibitor, as well as all special arrangements for display of goods, except tables and hangings, generally used for such purposes. Special information regarding exemption from duty for objects exhibited will be furnished as soon as the question is decided.

Blank applications and copies of regulations, sent by the embassy, are filed for reference in the Bureau of Foreign Commerce, where they may be consulted by parties interested.

Demand for American Machinery in Belgium.—Consul Winslow writes from Liege, February 17, 1902, that the business outlook in that part of Belgium is much brighter, and that there is a fine opening for American goods, especially labor-saving machinery. Belgian manufacturers are beginning to realize that in order to successfully meet the competition of the United States up-to-date machinery is necessary, and in the opinion of the consul there is in that country a market for this class of our exports. He says that he has recently had many calls for addresses of American firms engaged in various lines of manufacture, and that he is cognizant of an opportunity to furnish tools and machinery for an extensive rubber plant, as well as an outfit for a manufactory of enameled ware, communications in regard to which may be addressed to John Gross, rue Chevanfosse 13, Liege.

Trade Openings in Lourenco Marquez: Correction.—Consul Hollis writes from Lourenço Marquez that in his report dated September 11, 1901, he gave the address of Mr. Isaac J. Lithauer, American merchant, as Sun Court, Cornhill, London. Mr. Hollis has been requested to state that Mr. Lithauer's latest address is care of the United States Government Dispatch Agent, Trafalgar Square, London.

Liberian Tonnage Dues.—Consul-General Smith reports from Monrovia, January 20, 1902, that he has succeeded in inducing the Liberian government to secure the passage of a bill reducing the high tonnage rates (which operated more directly against American vessels, as European vessels usually carry Liberian mails) from 50 cents to 8 cents per ton.

Italian Demand for Stearin.—Under date of January 30, 1902, Consul Johnson, of Venice, says:

The demand in this district for American stearin, paraffin, and tallow is increasing, imports for the last quarter having shown a decided advance. I am in receipt of a communication from Mr. Guglielmo Olper, Calle dei Barcaroli, 1731, of Venice, asking to be put in communication with exporters of these materials.

German Demand for Oil Cake, Bran, Etc.—Consul Kehl reports from Stettin, January 31, 1902, that he has been asked to furnish a local house with addresses of wholesale manufacturers of corn oil cake, corn bran, and gluten feed. Correspondence addressed to the consulate, says Mr. Kehl, will be delivered to the firm in question.

Index to Advance Sheets of Consular Reports.

No. 1291. March 17.—Dalny, the Russian Commercial Seaport in North China.

No. 1292. March 18.—Wireless Telegraphy between Canada and Great Britain—Canadian Customs Free List Enlarged—Petroleum Briquettes in France—Brazilian-Chilean Trade—* Trade Conditions in Singapore.

No. 1293. March 19.—Projected Tariff of Switzerland—Coaling Facilities at Barcelona—* Yeast Wanted at Malta—Carrara Marble Exporters' Association—* Trade Openings in Lourenco Marquez—* Trade Openings in Poland.

No. 1294. March 20.—Commerce of France in 1901—International Amateur Rowing Race at Cork—Cane-Sugar Crop in Spain—Mineral Springs of Siberia.

No. 1295. March 21.—Brussels Sugar Convention—* American Ginseng in China—New Vine Disease in France—Russian Railroads in Persia.

No. 1296. March 22.—* How to Increase Coal Sales in Austria—German Wine and Grape Trade—Mexican Concession for Steamship Line and Fisheries—Railway Concession in Salvador—Operations of the Lima Mint for 1901—Congress of Historical Sciences at Rome.

The Reports marked with an asterisk (*) will be published in the Scientific American Supplement. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

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